# The Blast Furnace and Steel Plant

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The Blast Furnace and Steel Plant

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# "Heart, Head and Hands"

SEVERAL men were discussing, with the president of a large steel company, the success which had attended an innovation in plant practice recently put into effect. During the discussion the question was raised as to how it had been possible to achieve such extraordinary results as followed the introduction of this new movement. The president quickly replied, "Every man in our organization works with his Heart, Head and Hands. To no one person is the credit due."

As long as any company can get the whole hearted backing of the men in its organization it can push to success projects which otherwise would certainly fail. This undoubtedly is the reason why some firms succeed, in a certain line of endeavor, while others meet with only indifferent success.

To secure this form of co-operation is the aim of all plant managers. How to secure it is the problem.

Paternalism will not do it, neither will high wages alone. But if coupled to adequate remuneration, there is the sincere manifestation of interest in the employes' welfare a hearty response will, in the majority of cases, be forthcoming. Sincerity, justice, and respect are the fundamentals on which the president mentioned built his structure of plant management, and as it has endured for many years, it is evident that these attributes are basically essential to secure the hearty co-operation of any organizaton.

# What Goes on in the Blast Furnace

## A Study of Some of the Complex Reactions Taking Place in the Furnace. The Manner of Conducting the Investigations Is Related Together with the Results Obtained

IN his investigations of the blast furnace for the U. S. Bureau of Mines, S. P. Kinney, supervisor of ferrous metallurgy for that Bureau, spent about a year at the 300-ton furnace of the Central Iron & Coal Company at Holt, Ala., and wrote five reports which have been printed. Two of these, "Combustion of Coke at the Tuyere Level of the Blast Furnace," and Material and Heat Balance of a Southern Foundry Furnace," appeared respectively in The Blast Furnace and Steel Plant for June and July, 1925. The other three were recently issued by the Bureau of Mines as Technical Papers 390, 391, and 397, with the respective titles of "Occurrence, Distribution, and Significance of Alkali Cyanides in the Iron Blast Furnace," "Iron Blast-Furnace Reactions," and "Composition of Materials from Various Elevations in an Iron Blast Furnace."

### Description of Furnace and Procedure

Fig. 1 is a section of the blast furnace studied in these investigations. The charge consisted of Alabama red and brown iron ores, Alabama coke, limestone (dolomite), and nodules of pyrite sinter. The figure shows the 2½-in. sampling holes which were drilled through the lining at six different planes. A nipple and gate-valve attached to the shell provided an entrance to the furnace. Samples could be taken of the gas inside the furnace by means of a water-cooled sampling tube or of the material inside the furnace by opening the sample hole and allowing the stock to be blown out of the furnace into a metal container. In all, thousands of samples were taken.

### I. Occurrence and Production of Cyanides from Blast-Furnace Gas

The presence of alkali cyanides in the interior of the iron blast-furnace has been noted repeatedly during a period of almost 100 years, and has been studied more or less closely by a few metallurgists. Reliable information on the concentration of cyanides at various points inside of present-day blast furnaces is necessary in order to determine the desirability of attempting to recover the cyanides as a by-product. Furthermore, many operators have thought the cyanides have important effects on the production of iron by the furnace.

The maximum amount of cyanides that might be recovered is fixed by the quantity of alkali ($Na_2O$ and $K_2O$) contained in the raw materials fed to the furnaces. At present, reliable data are available only on the quantity of $K_2O$ in these materials. According to a survey made by the Bureau of Soils, based on the raw materials charged and metal produced during the period 1913-1920, the total potash, $K_2O$, fed into the blast furnaces of the United States is about 222,900 tons a year. This is equivalent to 308,000 tons of KCN or 60,000 tons of nitrogen a year. The weighted average content is 0.2 per cent $K_2O$. The average alkali content of the furnace charge at Holt was 0.28 per cent $K_2O$ and 0.18 per cent $Na_2O$.

There is no need here to describe the details of sampling (93 samples were taken), analysis and possible errors therein, and the calculations, but the summary and conclusions arrived at are as follows:

1—Previous work on the occurrence of alkali cyanides in the iron blast furnace is summarized.

2—A method for determining the alkali cyanide content of gases at different points in the interior of the blast furnace has been developed and the values for one furnace have been determined.

3—In the plane of the tuyeres and also in a plane 27 in. above the tuyeres the concentration of cyanides ranges from virtually nothing at the wall to about 3 or 4 ounces per 1,000 cu. ft. at the center of the furnace. In a plane 19¼ ft. above the tuyeres (at the base of the shaft) the content is about 3 ounces per 1,000 cu. ft. This figure was confirmed by large-scale collection, in which cyanide was removed from about 0.5 per cent of the total gas for a short time.

4—The concentration of alkali cyanide in the fume from the slag notch varied widely, but was usually of the order of 10 to 20 ounces of KCN per 1,000 cu. ft.

5—Analyses of samples of blast-furnace fume collected at the plane 19¼ ft. above the tuyers and at the slag notch are given.

6—Calculations made indicate that the concentration of alkali cyanide would not be greatly lowered by withdrawing a part of the gas for the recovery of cyanides.

7—It seems unlikely that the operation of the blast furnace would be adversely affected by the withdrawal of a small part of the gas for the recovery of cyanides. The amount of alkali cyanide recoverable in this way would be commercially significant.

8—If one-tenth of the gas at plane 4 be withdrawn it is estimated that the daily recovery of crude cyanide would be 1,040 lbs., which, at 10 cents a lb., would be worth $104.

### II. Reactions in the Blast Furnace

Many investigators have attempted to study the reactions at various elevations in the blast furnace. Usually the data have been obtained by taking gas samples at a single point through holes drilled in the shell of the furnace or by allowing a vertical pipe to descend with the stock. A few investigators reported temperatures and pressures. The first work available is a report by Bunsen and Playfair in 1845 at Alferton, England, who studied a furnace that used anthracite fuel. The results of Metz in 1913 and of Levin and Niedt in 1911 agree with those obtained in this investigation, although those investigators did not obtain comparable data because their observations were lmited to a single point on each plane.

The gas samples were obtained by means of a water-cooled sampling tube, as shown in Fig. 2. The sampling tube was driven through the opening in the furnace to the center with a dolly bar. At the tuyere

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plane and bosh, compressed air was used in the center, or gas line, to prevent stoppage with slag or other fused material. When samples were taken on planes higher in the furnace, where fused material was not encountered, a rod was used to prevent the plugging of the gas line. When the tube had been driven to the center of the furnace, the air was disconnected or the rod was removed and a rubber tube was connected to the ⅛-in. gas outlet pipe. This tube led to the point where the samples were taken. A small hook of ⅛-in. iron pipe was attached to the end of the rubber tube. At each setting of the sample tube, gas samples were collected over mercury in 4-ounce wide-mouth bottles closed with rubber stoppers. After a sample had been taken the bottle was inverted and set in a shallow trough of water, which acted as a secondary seal. A little mercury was left in each bottle, and when the bottle was inverted the mercury acted as a seal for the gas and as a covering for the rubber stopper.

The collection of gas samples continued over a considerable period. Sampling was started on plane 1, 3 ft. under the stock-line, and progressed from plane to plane until the tuyere level was reached. All samples were collected when the furnace was operating normally, and if operation seemed irregular the sampling was suspended until operation was normal. Each plane was sampled on several different days. Each day's work involved repeated sampling of the gases from the inwall to the center of the furnace, at intervals of approximately 4 in.

The tabulation following gives miscellaneous operating data:

| Temperatures of: | Deg. F. | Deg. C. |
|---|---|---|
| Blast | 957 | 513.8 |
| Top | 335 | 168.2 |
| Metal | 2,525 | 1,385 |
| Slag | 2,568 | 1,409 |
| Tuyere | 2,793 | 1,534 |
| Air at blowing engine, dry bulb | 65 | 18.3 |
| Air at blowing engine, wet bulb | 56.5 | 13.6 |

| | |
|---|---|
| Relative humidity, per cent | 55 |
| Moisture in air, grains per cu. ft. | 3.73 |
| Barometer | 29.64 |
| Pressures, pounds per square inch: | |
| Blast | 16.85 |
| Steam | 88.9 |
| Blowing engine: | |
| Revolutions per minute | 101.5 |
| Air blown, calculated from engine speed, dry, cu. ft. per minute at 65 deg. F., and 30 in. of mercury | 41,660 |
| Air blown, calculated from carbon consumption and gas analysis: | |
| Dry, cu. ft. per minute at 65 deg. F. and 30 in. of mercury | 28,691 |
| Wet, containing 3.73 grains of water per cu. ft. | 29,012 |
| Coke: | |
| Shatter test, per cent | 69 |
| True specific gravity | 2.00 |
| Apparent specific gravity | 0.99 |
| Furnace data: | |
| Volume of furnace, cu. ft. | 15,385 |
| Number of tuyeres | 12 |
| Size of tuyeres, in. | 6 x 12 |
| Charges per day | 71.4 |
| Iron made, tons a day | 324.7 |

## Conclusions

Some of the most pertinent points indicated by the results of gas sampling on planes 1 to 6 are as follows:

*Restricted Combustion Zone*—Combustion of coke in the hearth of the furnace is taking place in a comparatively restricted zone at the nose of each tuyere. Oxygen of the blast is consumed 30 in. in a horizontal direction and 27 in. in a vertical direction from the center of the nose of the tuyere. The $CO_2$ is reduced at a horizontal distance of 40 in. and probably at a like vertical distance. It may therefore be concluded that the process of combustion is taking place in a restricted zone within 40 in. of the nose of the tuyeres, as shown in Fig. 4.

*Inefficiency of Coke*—As combustion is taking place in a restricted zone at the nose of each tuyere, the carbon of the coke is being rapidly converted from the solid to the gaseous phase in this restricted combustion zone. A void is thus created toward which the stock is constantly flowing from all parts of the shaft. In other words, the extent of the combustion zone controls the movement of the stock in the upper part of the furnace. Stock lying directly over the combustion zone, like coal directly over a hole in the bottom of a coal bin, will move more rapidly in its descent toward the tuyeres than that at points farther removed, say, in the center of any plane. This fact has also been pointed out by experiments on models. These deductions lead to the conclusion that the movement of stock in the shaft is not uniform.

It is pointed out that as the product of combustion is CO, the net heat produced per pound of carbon burned is a constant—29,160 gram-calories—and all tuyeres are similar in this respect.

*Restricted Gas Flow*—Excess of nitrogen at the center of the furnace, at the tuyere plane, and at plane 5 indicates restricted gas flow at the hearth and bosh of the furnace, and reactions which produce CO, such as the oxidation of iron, the formation of cyanides, or the so-called reduction of metallic oxides.

*Bosh Gas*—The gases on plane 4, which is 19 ft. 3 in. above the center line of the tuyers, have been shown to have almost similar composition as bosh gas, whose composition is constant throughout the planes.

The analyses of gas samples on planes 1, 2, and 3 show certain similar characteristics: First, there is a high CO content in the gases near the wall and to a distance of about 40 in. from the wall. Second, after the 40-in. point has been passed the $CO_2$ falls rapidly, as the center of the furnace is approached, to approximately the proportion in bosh gas.

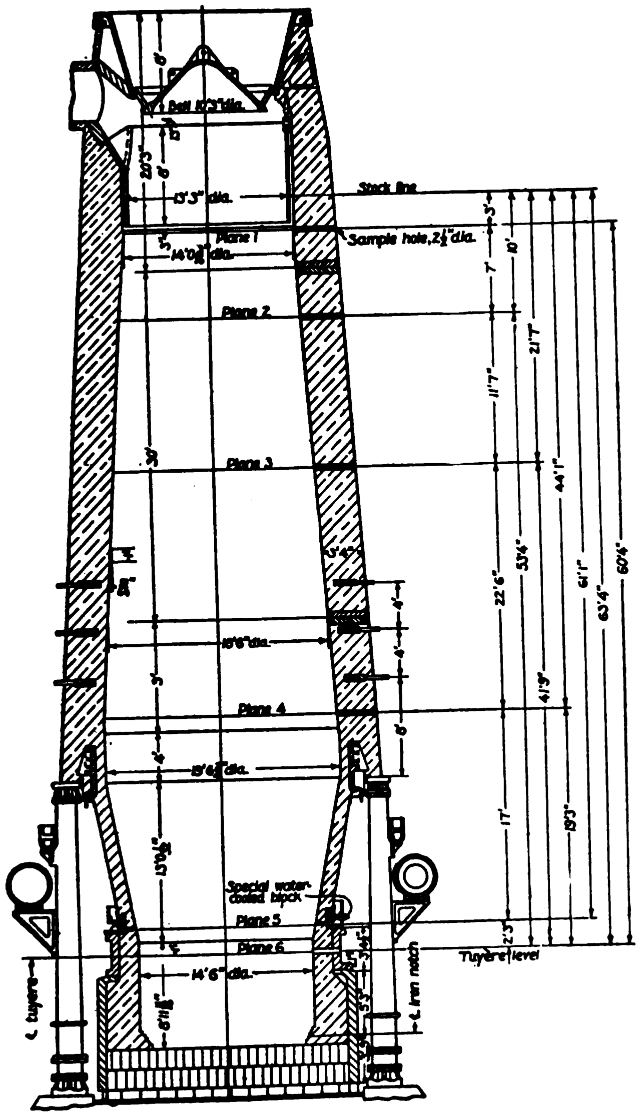
Gas sampling and integration of the $CO_2$ curves show that the $CO_2$ content of the gases increases with distance above the tuyere until plane 2 is reached; the gases then decrease in $CO_2$ content until the composition of top gas is attained at the top of the furnace.

Comparison of the average calculated $CO_2$ in the top gas from integration of the $CO_2$ curve from plane 1 and the observed average $CO_2$ content of the top gases indicates that the gas flow per unit area of plane 1 is approximately uniform, but does not indicate uniformity of flow in the lower part of the shaft.

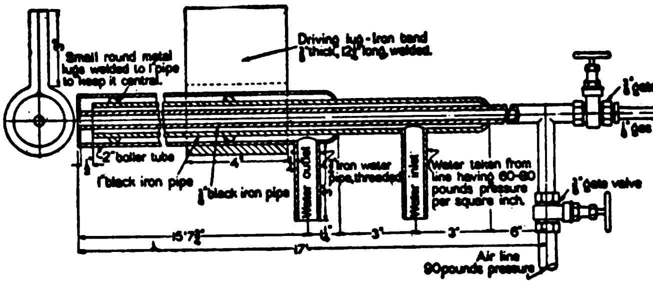
*Cause of Uneven Distribution of Carbon Dioxide*—If it is assumed that the flow of gas per unit area of any one plane is uniform and the descent of stock is not, because of the restricted zones of combustion, a furnace shaft can be pictured in which the gas flow is fairly uniform or possibly slightly faster in the center from the porosity of the charge, and in which the movement of stock downward is comparatively rapid close to the walls and for 40 in. from them and comparatively slow in the center. If the iron oxide were charged so that it would lie in uniform layers, then through the non-uniform flow of stock more iron oxide would pass any unit area of the 40-in. ring per unit of time than would pass a like area in the center of the plane. It is known, however, that the greater part of the oxide is near the wall, therefore the amount of reduction is greater in the outer ring per unit of area and time, which accounts for the resultant higher $CO_2$ in the gases from this part of any plane. As the movement of stock in the center area is comparatively slow, the iron oxide is rapidly reduced with a small accompanying effect on the $CO_2$ content of the gases. The cause of this condition—that is, high $CO_2$ near the wall and low $CO_2$ in the center—can be directly attributed to the restricted combustion zones at the tuyere level and the resultant uneven flow of stock throughout the shaft.

Again, if the method of charging a furnace is considered, the distribution of ore on any plane is uneven; the largest amount per unit area tends to be near the walls of the furnace and a small amount in the center. The fine material remains near the wall and the coarser tends to go to the center. This condition would bring us to the same conclusion—that is, that more reduction per unit area and time is taking place near the wall, which would account for the higher $CO_2$ at that point.

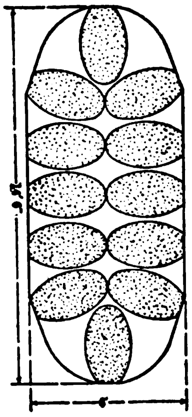
*Probable Effect of Rearrangement of Combustion Zone*—It is suggested that a rearrangement of the combustion zone, as shown in Fig. 3, would produce



1


Small round metal lugs welded to 1" pipe to keep it central.
Driving lug-iron band ⅜" thick, 12½" long, welded.
½" gate valve
½" gas outlet
2" boiler tube
1" black iron pipe
⅜" black iron pipe
Water outlet
Iron water pipe, threaded
Water inlet
Water taken from line having 60-80 pounds pressure per square inch.
½" gate valve
15'7½"
3"
3"
6"
17'
Air line 90 pounds pressure

2



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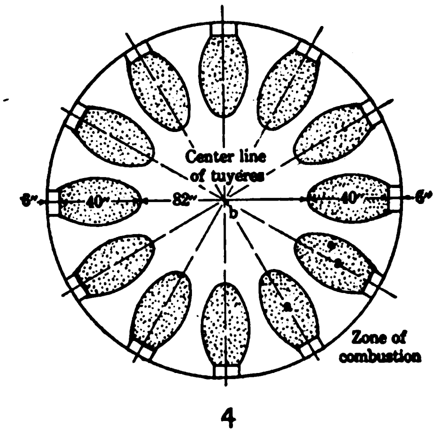

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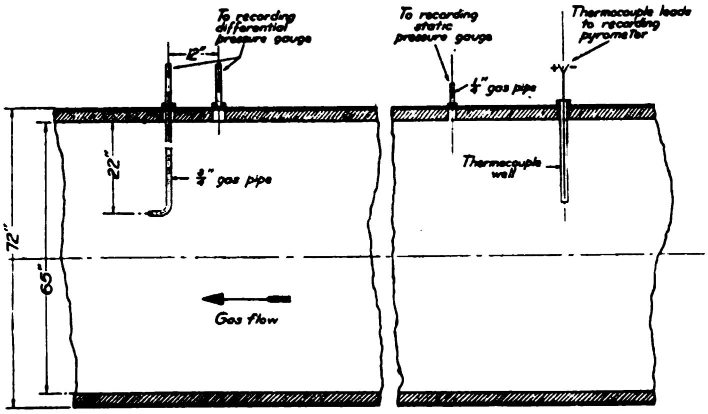
To recording differential pressure gauge
12"
22"
¾" gas pipe
72"
65"
Gas flow
To recording static pressure gauge
¼" gas pipe
Thermocouple leads to recording pyrometer
Thermocouple well

5

**FIG. 1—Section of blast furnace, showing holes through lining for sampling gas and materials from the interior. FIG. 2—Water-cooled gas-sampling tube. FIG. 3—Diagram showing oxidizing and reducing zones in a proposed blast-furnace hearth. FIG. 4—Plan of tuyere plane, showing penetration of combustion zones (a). FIG. 5—Sketch showing measuring devices.**

a more uniform flow of stock, more efficient contact between gas and solid, and a lower consumption of coke.

## III. Composition of Materials at Various Elevations in the Blast Furnace

Samples of stock were collected from the interior of the furnace by opening the sample hole and allowing the stock to be blown out of the furnace into a metal container; these samples were allowed to cool in an air-tight metal container in a reducing atmosphere.

Samples from hole 5, which is 27 in. above the center line of the tuyeres, were collected by allowing the fused material to blow or run out of the furnace into the container.

A number of samples were collected from the center of the furnace at the tuyere level by drilling gas-sampling tubes which had been plugged while in the furnace. The position of the end of the sampling tube when plugged was noted.

About 1,000 gas samples were taken to determine the gas composition at the various planes.

### Conclusions

The summary of the investigations and conclusions derived therefrom are as follows:

1—Results of sampling stock and gas in the upper part of the blast furnace show that 80 to 85 per cent of the iron in the burden has been reduced to the metallic form by the time it has reached a point 19¼ ft. above the tuyere level.

2—Metal in the form of sponge iron has taken up, or is in intimate contact with, considerable quantities of carbon, sulphur, phosphorus, manganese, and silicon by the time it has reached plane 4, which is 19¼ ft. above the tuyere level and 8 ft. above the bosh level.

3—About 87 per cent of the silicon entering the metal is taken up while the metal is in the bosh above plane 5, and the 12 per cent is taken up between plane 5 and the crucible, 27 in. above the center line of the tuyeres and the crucible.

4—Silica in the coke ash has little effect on the amount of silicon in the metal, because the metal has obtained most of its silicon before it reaches the tuyere level.

5—Approximately one-third of the manganese enters the metal or is intimately associated with it above plane 4. The manganese content of 15 casts was 0.53 per cent; metal samples from planes 4 and 5 contained 0.22 and 1.10 per cent, respectively. Between planes 4 and 5 the metal takes up considerable manganese, part of which is probably oxidized later in the tuyere zone.

6—All of the phosphorus has entered the metal by the time the metal has reached plane 5. Approximately one-half of the phosphorus has entered or become intimately combined with the metal at plane 4.

7—More than one-third of the carbon has been taken up by the metal by the time it reaches plane 4; the remainder is taken up while the metal is in the bosh of the furnace and before it reaches the level of the tuyeres.

8—The tolerant limit on sulphur is 0.05 per cent. At planes 4, 5, and 6 the metal contained approximately 140, 360, and 140 per cent, respectively, of the tolerant limit. At plane 4 the metal had taken up 3.33 per cent of the sulphur which had been charged into the furnace, while at plane 5 the metal had taken up 12.0 per cent of the available sulphur. The results show the ease with which the metal has taken up sulphur in the upper part of the furnace; they also readily show that the metal continues to take up sulphur while it is in the bosh of the furnace, probably because part of the metal is not covered by slag and therefore is subject to contamination with sulphur produced from combustion of coke at the tuyere level.

9—Determination of forms of sulphur in coke samples at plane 4 shows that approximately 25 per cent of the sulphur has been removed from the coke by the time that it reaches this plane, and the sulphur which has been removed is what existed in the coke as ferrous sulphide and free sulphur. About half of the ferrous sulphide and free sulphur has been removed at plane 4.

10—Analyses of samples of limestone taken from plane 4 show that the lime has taken up 0.77 per cent sulphur, which is approximately 26 per cent of the available sulphur originally charged. Coke at this point has lost 25 per cent of its sulphur and the metal has taken up 3.33 per cent of the available sulphur. Preferential absorption of sulphur by lime in the upper part of the furnace is demonstrated by these results.

## IV. Further Blast-Furnace Gas Studies

In Technical Paper 401 of the Bureau of Mines, recently available, J. F. Barkley describes the studies made at the Edgar Thomson Works of the Carnegie Steel Company, at Braddock, Pa. One main object was to discover what relation existed, under regular operating conditions, between the amount of gas produced and the pounds of coke used per ton of iron. Another object was to determine what were the variations from day to day between the amount of gas actually produced and the amount found by calculation from the furnace charges. Included in these studies was the plotting of the main items of observation in simple relation in order to bring out any consistencies of blast furnace action in the production of gas.

The work required that the gas produced by different furnaces be measured over a period of months. Three large furnaces designated F, G, and H were used. Measurements was made at furnace F for one month, at furnace G for about two months, and at furnace H for two months. The gas was measured in the hot, dirty state while flowing through a gas line about 6 ft. in diameter.

The method of measurement was an adaptation of the Pitot tube method, as is shown in Fig. 5; the velocity tube, instead of pointing upstream against the flow, as is usual, pointed downstream. This position gave a smaller pressure difference between the two tubes for a given flow than the usual method; but, for the velocities measured in these tests, the differential was of sufficient magnitude to be measured with the necessary accuracy. This variation of the Pitot tube method largely reduced the difficulties caused by tubes continually being stopped up with dust in the gas. Sometimes the static tube would become clogged after several days, so that as a part of the usual daily attention to the set-up both tubes were blown clean by the removal, for a few moments, of pipe plugs in the lines connecting the differential pressure gage. The pressure in the gas main quickly cleared the tubes.

### Results in Brief

The results may be set down as follows:

1—Carbon goes into the furnace in the coke and in the limestone; it goes out in the gas, in the iron, and in the downcomer dust. As for much blast-furnace practice, the carbon that enters the furnace in the limestone closely equals that going out in the iron plus that lost in the downcomer dust, the total gas can be calculated within probably 2 per cent by using the coke tonnage only. However, in the calculations the carbon in the limestone and iron was used in order to protect the calculations from any possible erratic furnace working that might confuse the comparisons. The carbon in the downcomer dust was almost constant, and was considered as 1 per cent.

2—Comparison of the gas as measured and as calculated showed that the daily divergence is considerable (15 per cent more, or less), but the monthly average is fairly close (1.2 per cent). The great quantities, volumes, and sizes involved in this investigation facilitated the obtaining of accuracies of measurement.

### V. Reduction of Manganiferous Iron Ores in the Blast Furnace

A co-operative report, Bulletin 12 of the University of Minnesota, by T. L. Joseph and S. P. Kinney, describes the trials and results of reducing 100 per cent charges of Minnesota manganiferous iron ore in the 6-ton furnace of the University and Bureau of Mines at Minneapolis. First, the domestic resources of manganese ore are considered, then the chemical and metallurgical uses of manganese, and next the domestic requirements.

Under existing practice, sufficient manganiferous iron ores are added to the blast-furnace charge to produce pig iron to contain approximately 2 per cent manganese. In the smelting process about 75 per cent of the manganese is recovered in the metal and the major portion of the 25 per cent remaining passes into the slag. The presence of manganese in the charge aids desulfurization of the iron in the lower part of the furnace. It also makes a more fluid slag and one with a lower free-running temperature. There are differences of opinion regarding the magnitude of the benefits derived from manganese in the blast furnace and open-hearth furnace, but the practice is growing.

The charge of ordinary iron ore and manganiferous iron ore smelts without difficulty, but it was not known what would happen with a 100 per cent charge of the latter, consequently seven runs were made with the experimental furnace on ore containing 8.24 per cent Mn, 33.78 per cent Fe, 8.12 per cent $SiO_2$, 5.98 per cent $Al_2O_3$, 0.26 per cent P, and 17.13 per cent moisture. The iron produced (150 tons) contained 4.57 per cent C, 12.23 per cent Mn, 0.24 per cent Si, 0.55 per cent P, and below 0.01 per cent S. The runs proved that it is feasible to smelt an ore burden made up entirely of the brown type of manganiferous iron ores from the Cuyuna Range; also, considerable fundamental information was obtained on the production of ferro-alloys in the blast furnace.

## Discussion of Paper, "Theory of Blast Furnace"

**Blast Furnace and Steel Plant, June, 1927**

**By S. P. KINNEY**

The Bureau of Mines in co-operation with the Fixed Nitrogen Research Laboratories of the Department of Agriculture conducted an investigation for the purpose of determining the effect of the formation of cyanides on operation and the extent of their presence. The investigation has been reported in full in a number of places.*†

Briefly it might be said that the cyanide concentration (as KCN) at the tuyere level, at a plane 27 in. above the tuyeres and at a plane 19¼ ft. above the tuyeres was less than 3,47 oz. (0.22 lb.) per 1,000 cu. ft. of gas.

The above concentration indicates that 0.06 per cent of the nitrogen entering the furnace has combined to form cyanides and that approximately 0.3 per cent of the available hearth heat has been consumed in cyanide formation.

Mr. Franchot indicates that 4 per cent of the air nitrogen takes part in nitrogen fixation as against 0.06 per cent found by the Bureau. Four per cent nitrogen fixation is equivalent to approximately 9 lb. per 1,000 cu. ft. as compared with the Bureau's findings of 0.22 lb. per 1,000 cu. ft.

Mr. Franchot has attacked the Bureau's results and method of investigation; such an attack, if accompanied by sufficient original data to substantiate conclusions, should be considered, but until Mr. Franchot or some other investigator proves that there are concentrations of cyanides in the hearth or bosh of the blast furnace in sufficient quantities to materially limit the burden charged and affect the coke consumption, it would only seem logical that the findings of the Bureau should stand.

It does not seem to the writer that Mr. Franchot has submitted sufficient evidence to uphold the statement that: "Cyanide accumulation has been found sufficient to account in vaporization for over 30 per cent of the coke burned to keep the hearth hot," or that, "There can be little doubt that at present the mechanical difficulties, evidenced by hanging, sticking, and slipping, are enhanced by the condensation in the shaft of volatile, saline substances, such as cyanides and of slags which are vaporized in the hearth and carried up in the gas."

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*S. P. Kinney and E. W. Guernsey, the occurrence of alkali cyanides in the iron blast furnace: Jour. Ind. and Eng. Chem., vol. 17, No. 7, July, 1925, p. 670, and Blast Furnace and Steel Plant, vol. 13, October, 1925, pp. 395-399.

†S. P. Kinney and E. W. Guernsey, occurrence, distribution and significance of alkali cyanides in the iron blast furnace: Tech. Paper 390, Bureau of Mines, 1926, 37 pp. Government Printing Office.

## General Electric Orders

Orders received by the General Electric Company for the three months ending June 30 amounted to $78,105,247 compared with $78,972,062 for the second quarter of 1926, a decrease of one per cent, President Gerard Swope has announced.

For the six months ending June 30, orders totalled $155,655,828, representing a decrease of six per cent compared with $165,405,720 in the corresponding six months of 1926.

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# Motor Drives for Elevators and Conveyors

## After Explaining the Application and Operation of Machinery for Transporting Materials the Author Gives the Characteristics of the Motors Which Should be Used

By GORDON FOX*

SHORT distance transportation of materials is accomplished by intermittently operating devices such as cars, cranes and trucks or by continuous conveyors. This chapter deals with the latter class.

Mechanical conveyors may be classified as of the following general types:

Bucket elevators,
Screw conveyors,
Scraper conveyors,
Belt conveyors,
Pan or apron conveyors,
Pivoted bucket carriers,
Special conveyors.

A bucket elevator is commonly used for elevating vertically or on a steep incline for relatively short distances. This type of elevator comprises a series of buckets attached rigidly to and spaced at intervals on a belt or a chain.

There are two types of bucket elevators differentiated as to method of delivery of the material at the top of the elevator. In the intermittent bucket type, independent buckets are spaced some distance apart along the belt. The buckets discharge as they pass over the head pulley, centrifugal force carrying the material clear and out into the chute. In the continuous bucket type of elevator the buckets are spaced close together and the bottom of one overturned bucket serves as a chute for the material being delivered by the bucket above it. The close spacing of buckets gives this type of elevator a large capacity for a given speed. In this type of elevator the material is not thrown by centrifugal force.

### Speeds

The proper speed of a centrifugal delivery bucket elevator is determined largely by the requirements for delivery of material at the head pulley. This depends, to some extent, on the diameter of the head pulley and the weight and character of material handled. If the speed be either too high or too low the discharge will not be clean and excessive spillage may result. The speed should not be greater than necessary for clean discharge in order to minimize wear on the buckets and belt or chain and head chute and also, in some cases, to avoid breakage of material.

TABLE I

Speeds for Centrifugal Discharge Vertical Bucket Elevators

| Diameter of head wheel | Rev. per Minute<br>Grain | Rev. per Minute<br>Coal, ore, cinder and coarse material | Linear or Belt Speed<br>Grain | Linear or Belt Speed<br>Coal, ore, cinder and coarse material |
|---|---|---|---|---|
| 18 | 56 | 46 | 264 | 217 |
| 24 | 50 | 41 | 314 | 257 |
| 30 | 45 | 37 | 353 | 290 |
| 36 | 41 | 34 | 386 | 320 |
| 48 | 37 | 30 | 465 | 377 |
| 60 | 33 | 27 | 518 | 424 |

The speed should also be correct, in relation to the diameter of the foot pulley and boot shape, to give good loading conditions. Vibration and excess friction may be also associated with high speeds. Mr. Hetzel, in his recent book "Belt Elevators and Belt Conveyors" gives the speeds shown in Table I. The values given are qualified by a number of conditions, however, and the reader is referred to the book for a full discussion of the subject.

Continuous-bucket type elevators may be either belt or chain type, there being much diversity in designs. This general class of elevators are usually operated at speeds ranging from 100 to 200 ft. per min., depending upon size, type and class of material handled. Inclined elevators, in general, are operated at lower speeds than vertical elevators. Inclined centrifugal discharge elevators commonly range in linear speed from 125 to 200 ft. per min.

### Power Required

The power required to drive a bucket elevator depends upon the type, speed, relative weight and finish of mechanism, etc. The load involves friction loss plus the power required to raise a given weight of material in a given time. It is a common practice to calculate the useful work and to cover the losses by allowing an efficiency of 40 to 60 per cent, according to type of equipment. Chain type elevators, in general, have lower efficiency than belt-bucket elevators. In figuring power, the buckets should be considered as full, while in figuring capacity, about 75 per cent filling is generally taken. To allow for digging in the boot, about 10 additional bucket loads should be included in the lift.

A simple approximate formula for power required by belt elevators is given below. The method outlined in the previous paragraph is to be preferred however

$Hp. = 0.001\ W.H.$
$W$ = weight of load elevated—tons per hour.
$H$ = height of elevation of load—ft.
$e$ = efficiency—decimal.

### Screw Conveyors

Screw conveyors comprise a trough or pipe in which a screw revolves, moving the material forward in so doing. This type of conveyor is usually horizontal, but may be inclined up to about 20 degrees with little loss in capacity. Inclined conveyors should be run at slightly lower speeds than horizontal screw conveyors to avoid throwing materials over the flights. The screw conveyor is confined largely to fine, light materials such as grain, flour, cement and fertilizer. It should be operated with the material coming only about to the center of the shaft or below, otherwise the material will tend to crowd against the bearings. This type of conveyor is simple, has low first cost is easy to feed and discharge. The fact that it mixes materials as they travel through it is sometimes of advantage. This type of conveyor is low in efficiency, requiring relatively large driving power. It tends to grind and break material in transit. If the material is at all abrasive the wear and tear on the conveyor is high.

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*Freyn Engineering Company.

Screw conveyors should not be unduly long; about 200 ft. is the limit for a 6-in. conveyor and 300 ft. for a 9-in. conveyor. The drive should be located so that the material will be pulled toward the drive and rather pushed from it. Breakage of a part will then cause the elevator to clear rather than clog or pile and the shaft, being in tension, will not tend to buckle.

The capacity of a screw conveyor is proportional to the speed, weight of material and pitch of screw. In most commercial conveyors the pitch is equal to the diameter.

**TABLE II**

**Speed and Capacity of Typical Screw Conveyors.**
**Material weighing 50 lbs. per cu. ft.**

| Screw Diameter | Rev. per Min. | Tons per hour |
|---|---|---|
| 4 | 220 | 2.26 |
| 6 | 195 | 6.77 |
| 8 | 175 | 14.40 |
| 10 | 160 | 25.70 |
| 12 | 150 | 41.64 |
| 16 | 130 | 85.54 |
| 24 | 100 | 222.00 |

The following empirical formulas may be used to determine the power requirements of average screw conveyors. Hp. required for horizontal screw conveyor:

$$\text{Hp.} = \frac{(0.00064\ dR + 0.446\ W)\ L}{1000}$$

Hp. required for inclined screw conveyor:

$$\text{Hp.} = \frac{(0.00064\ dR + 0.446\ W)\ L + WH)}{1000}$$

d = diameter of conveyor, inches.
R = Rpm. of screw.
W = weight material conveyed, tons per hour.
L = length of conveyor—ft.
H = height of elevation—ft.

The scraper conveyor comprises essentially a chain or pair of chains operating over or in a trough. At intervals along the chain flat scrapers are attached at right angles to the chain. These drag through the trough, scraping the material in the trough before them. Scraper conveyors are relatively simple and cheap. They can be loaded at several points and can be discharged at any desired point. They are not well suited for use with abrasive materials. They are inefficient and require rather high driving power. They are used for handling dirt, ashes, coal, wood refuse and similar materials. They may convey horizontally or either up or down inclines as steep as 35 to 45 deg. from the horizontal. The speed of travel ranges from 10 to 200 ft. per min. The lower speed is associated with sorting conveyors, as at coal breakers. Speeds on the order of 100 ft. per min. are most frequent.

The power requirements of scraper conveyors may be obtained by the following empirical formulas.

To run a conveyor empty:

$$\text{Hp.} = \frac{0.254\ WL}{1000}.\ \text{For sliding shoe flights.}$$

$$\text{Hp.} = \frac{0.166\ WL}{1000}.\ \text{For roller flights.}$$

To convey load horizontally, including losses:

$$\text{Hp.} = \frac{0.954\ WL}{1000}.\ \text{For sliding shoe flights.}$$

$$\text{Hp.} = \frac{0.866\ WL}{1000}.\ \text{For roller flights.}$$

To convey load on inclines, including losses:

$$\text{Hp.} = \frac{0.954\ WL}{1000} \pm \frac{WH}{1000}.\ \text{For sliding shoe flights.}$$

$$\text{Hp.} = \frac{0.866\ WL}{1000} \pm \frac{WH}{1000}.\ \text{For roller flights.}$$

The + sign is used where the material is conveyed up the incline. The — sign applies where the material is conveyed down the incline.

W = weight load in tons per hour.
L = length of conveyor—ft.

## Belt Conveyors

Belt conveyors are used extensively for handling bulk materials. They are in common use for distances up to 1,000 ft. and are used not infrequently for somewhat longer distances. They are relatively simple, have high carrying capacity and fairly low power consumption. They are quiet and positive in operation. They do not ordinarily damage material in transit. They may be loaded and discharged at any point, although with some difficulty. They are relatively light in weight. Belt conveyors are relatively high in first cost. They have a minimum of wearing parts. The belt is subject to damage and replacements are expensive as the belt usually represents one-third to two-thirds of the cost of the installation.

Belt conveyors may be used on inclines up to 17 deg. for run of oven coke; 18 deg. for run of mine coal, broken stone, ore and gravel and 20 deg. for coke breeze, slack coal and sand. For wood chips, wood pulp and a few other materials 22 or 23 deg. inclination is allowable.

The speed of a belt conveyor is absolutely limited with grain, by air resistance, which will blow off the material conveyed. Moderate speeds are generally desirable to minimize damage to the belt from abrasion in loading and to avoid violent discharge of the material in unloading. The ability to feed rapidly and evenly is often a limiting factor. If speeds are too high the material thins out on the belt. It is not economical to run a belt lightly loaded as the power consumption is relatively high and the belt wear also increased per unit of output. If it is found that a belt is not being run fully loaded, it is good economy, if feasible, to reduce the belt speed and permit heavier loading. At high speeds the idler pulleys may vibrate due to unbalance and wear and tear is increased. Belts loaded on an incline must run slower than those loaded on the horizontal. Wide belts may be operated at higher speeds than narrow belts. Flat belt conveyors carrying packages and miscellaneous articles are operated at about 100 ft. per min. The following are maximum advisable speeds:

### TABLE III
### Speeds for Belt Conveyors

| Belt width, Inches | Maximum speed—ft. per min. Coal, ore, gravel, etc. | Grain |
|---|---|---|
| 14 | 300 | 350 |
| 20 | 350 | 500 |
| 24 | 400 | 600 |
| 30 | 450 | 650 |
| 36 | 500 | 700 |
| 48 | 600 | 800 |

### Capacity

The capacity of troughed conveyors may be closely approximated by the following formula. The capacity varies with materials, incline and loading conditions. The formula refers to a fully loaded belt traveling at 100 ft. per min. Capacities at other speeds are proportionate.

$$W = \frac{3.5 \times w^2 \times G}{2000}$$

W = Capacity—tons per hour—at 100 ft. per min.
w = belt width—inches.
G = weight of material—lbs. per cu. ft.

### Power Required

Belt conveyors are relatively efficient and require less power than other types of conveyors. The power required by belt conveyors is subject to considerable variation, depending upon conditions. The following empirical formulae will closely approximate the correct values in most instances.

To run conveyor empty—power at head pulley:

$$\text{Hp.} = \frac{KVL}{2000}$$

To convey and elevate or lower a load—power at head pulley:

$$\text{Hp.} = \frac{(KV - 0.071\ W)\ L}{1000} \pm \frac{WH}{1000}$$

The + sign applies when material is elevated up an incline. The — sign applies where material descends an incline.

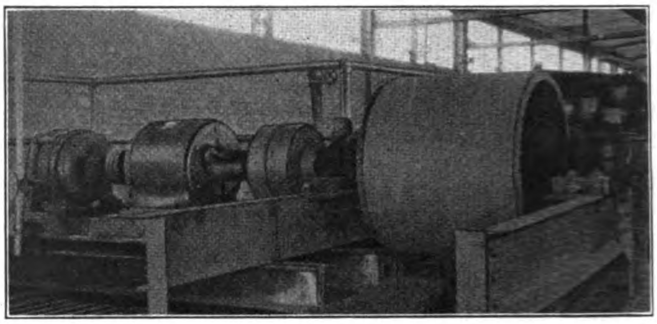
V = belt speed, ft. per min.
W = delivery, tons per hour.
L = belt length between pulley centers—ft.
H = lift—ft.
For horizontal conveyors — H = 0.
K = constant having the following values:

| Belt width, Inches | Constant K | Add for each tripper |
|---|---|---|
| 14 | 0.023 | 1 hp. |
| 16 | 0.032 | 1 hp. |
| 18 | 0.041 | 1.5 hp. |
| 20 | 0.052 | 1.5 hp. |
| 24 | 0.061 | 2.0 hp. |
| 30 | 0.075 | 2.5 hp. |
| 36 | 0.108 | 3.5 hp. |
| 48 | 0.148 | 6 hp. |

For each tripper add 1 to 6 hp. according to width of belt. The above formulae give horsepower values at the head pulley. Where there are belt or gear reductions between this and the motor, the efficiency of this mechanical transmission must be considered and horsepower values increased 5 per cent to 15 per cent as necessary. The horsepower values found by the above formulae are too low for short conveyors due to relatively high friction of terminal pulleys. Increase the values found by the formulae as follows:

| L | Increase hp. |
|---|---|
| 50 ft. and under | 20 per cent |
| 50 to 100 ft. | 10 per cent |
| 100 to 150 ft. | 5 per cent |

The formulae and data above given apply to the ordinary installation with grease lubricated idler pulleys. If ball or roller bearings are used, some reduction in power requirement is made. There is comparatively little data on this subject but it appears that the purely frictional load (as constrasted with the elevating component) may be considered as reduced 25 per cent. The friction load is not due to bearing friction alone, but other elements, such as belt flexure also enter.



**Belt conveyor with head-pulley driven through gear-reduction unit.**

The power required by a belt conveyor may be increased as by excess belt tension or by friction of material at the skirt boards. Too small head pulleys require excess belt tension and increase the friction load. The use of too few troughing idlers also tends to increase the load. It is desirable that a belt conveyor be started empty and brought up to full speed before loading, but as this is not always possible, the motor should be able to start with the belt fully loaded. Preferably the belt should not be stopped until fully unloaded, particularly if inclined.

### Apron Conveyors

Apron or pan conveyors comprises two strands of roller chain between and to the links of which are attached flat, beaded or specially shaped slats or flights. This type of conveyor is similar in action to the belt conveyor, but may be used where the belt conveyor may not be adapted such as for heavy or sharp materials or for inclines greater than 20 deg. Flight conveyors are slower and more cumbersome than belt conveyors. When used primarily for conveying service they operate at speeds ranging from 60 to 120 ft. per min. When used in connection with industrial processes as for continuous molding and pouring, continuous assembling or inspecting or for heating operations, very slow speeds may be necessary. Due to the many joints the wear is apt to be rather high. Variations in design and application prevent determination of power requirement from any simple formula. The power required by this type of conveyor will ordinarily exceed that required by a belt conveyor for similar work.

### Pivoted Bucket Carriers

Pivoted bucket carriers comprise essentially a series of buckets suspended between two endless chains. The chains are provided with rollers running on tracks provided along the horizontal portions of the run. The buckets are suspended from central pivots so that they remain upright except when inverted by a tripper. The conveyor ordinarily takes the form of a loop with two horizontal and two vertical runs.

As these conveyors carry the material in buckets they do not tend to damage it. They are often used for conveying coal. The fact that they serve both to elevate and distribute horizontally may be of advantage in avoiding a transfer from an elevating to a distributing means. They may be discharged at any number of tripping points along the horizontal portion of their run. They are fairly efficient. They are normally slow speed equipments, operating at 40 to 60 ft. per min. The drive is usually located at the head of the down-going strand. The power required depends upon the proportion of the vertical and horizontal sections.

There are many special types of conveyors such as cooling racks, chain transfers, pig casting strands, conveyors for dipping materials, etc. These are, in general, similar to the standard types in fundamental principles, but each has its special features. It is this class of conveyors, particularly, which may require adjustable speed drives.

(To be continued)

## Papers to Be Read Before American Society for Steel Treating Convention

Over 45 papers representing practically every phase in the metal industry, will be presented at the annual convention of the American Society for Steel Treating to be held in Detroit the week of September 19, the same time as the National Steel and Machine Tool Exposition.

The technical quality of the papers presented at the A.S.S.T. conventions has been of high caliber and those to be given this year, as listed below, are upon the same high plane.

In addition to the technical sessions of the American Society for Steel Treating, there will be held at the same time the fall meeting of the Institute of Metals, the annual meeting of the American Welding Society and the production meeting of the Society of Automotive Engineers.

The schedule of papers to be presented at the Detroit convention is as follows:

### TECHNICAL PAPERS PROGRAM

### NINTH ANNUAL CONVENTION
### AMERICAN SOCIETY FOR STEEL TREATING
### DETROIT, MICH.
### SEPTEMBER 19-23, 1927

#### Monday Morning, September 19

"Deep Etch Method of Testing Steel"—H. G. Keshian, Chase Metal Works, Waterbury, Conn.

"Metallurgy and Aircraft"—H. C. Knerr, Germantown, Philadelphia.

"Uses of Gas in Steel Treating and Forging"—W. M. Hepburn, Surface Combustion Company, Bronx, New York City.

"Hardening by Reheating After Cold Working"—M. A. Grossmann and C. C. Snyder, Central Alloy Steel Corporation, Canton, Ohio.

"Practical Experience in the Field of Heat Treatment of Wire and Rods for the Making of High Strength Wire by the Process of Patenting"—J. S. G. Primrose, Manchester, England.

#### Monday Afternoon

"Fatigue Strength of Case Carburized Steel"—N. J. Alleman and H. F. Moore, University of Illinois, Urbana, Ill.

"Corrosion Fatigue of Alloys of Nickel, of Copper and of Aluminum"—D. J. McAdam, Jr., Engineer Experiment Station, Annapolis, Md.

"Testing Automobile Body Sheet Steel"—Joseph Winlock and G. L. Kelly, E. G. Budd Mfg. Company, Philadelphia.

"Graphic Magnetic Pictures of Internal and External Stress"—A. V. DeForest, American Chain Company, Bridgeport, Conn.

"A Critical Study of the Bend Test as Applied to Iron and Steel"—A. B. Kinzel, Union Carbide & Carbon Research Laboratory, Long Island City, N. Y.

#### Tuesday Morning, September 20

"Steel Melting Practice"—W. H. White, Duquesne Steel Foundry Company, Coraopolis, Pa.

"The Melting Stage of Steel Making"—G. A. Dornin, Gathmann Engineering Company, Baltimore.

"Armco Ingot Iron"—R. L. Kenyon, American Rolling Mill Company, Middletown, Ohio.

"The Manufacture and Uses of Wrought Iron in Present Day Industry"—James Aston, Carnegie Institute of Technology, Pittsburgh.

Another session will be held on Tuesday morning during which time the following papers will be presented:

"Carburizing Iron By Mixtures of Hydrogen and Methane"—W. P. Sykes, General Electric Company, Cleveland.

"Physical Properties of Nitralized Steel"—V. O. Homerberg, Massachusetts Institute of Technology, Cambridge, Mass.

"Gas Carburization of Steel"—R. G. Guthrie and Dr. O. J. Wozasek, Peoples Gas Light & Coke Company, Chicago.

"Studies of Normal and Abnormal Carburizing Steel"—O. E. Harder, L. J. Weber and T. E. Jerabek, University of Minnesota, Minneapolis.

#### Tuesday Afternoon

"Cutting Carbides"—H. M. German, Universal Steel Company, Bridgeville, Pa.

"Manufacture and Use of Hacksaw Blades"—H. B. Allen, Henry Disston & Sons, Inc., Philadelphia.

"Evaluating Quality of High Speed Steel Tools"—J. B. Mudge, Western Electric Company, Chicago.

"The Constitution of Hardened Steels"—W. P. Sykes and Zay Jeffries.

#### Wednesday Morning, September 21

Annual meeting of American Society for Steel Treating, J. F. Harper, Chairman.

"Campbell Memorial Lecture"—Zay Jeffries.

(Continued on page 381)

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# The Centrifugal Casting Process

## The Art of Centrifugal Casting Is Reviewed from 1809 to the Present — deLavaud Process Employed for Casting Pipe Fully Explained—Other Methods Given Brief Mention

By **JOHN D. CAPRON***

SINCE the inception of the foundry industry a large proportion of the castings produced have been annular in form. Undoubtedly, in early times before advances in foundry practice made it possible to cast intricate sections, the proportion of circular casting was even greater than it is today. It is not surprising, therefore, that early foundrymen were much interested in the development of a process which would improve castings of this type or reduce the cost of producing them.

We are accustomed to think of centrifugal casting as a new development in the industry and so little has been written on this subject that it is only recently that it has attained the dignity of a separate heading in the various technical indexes of the country. However, we should not overlook the early pioneers or their inventions.

### Early Developments in Centrifugal Casting

Over a hundred years ago, in 1809, Anthony G. Eckhart of England patented a method of casting by centrifugal force to "render the cast more perfect and neat." Eckhart's patents covered the casting of hollow bodies of various shapes and his illustrations show molds rotating around vertical, horizontal and inclined axes. A combination of rotation around two axes was used to form spherical bodies.[1] Although his patents were correct in theory, very little information was given as to the method of rotating the molds and insofar as is now known, his invention was never used.

An American, Thomas G. Lovegrove of Baltimore, is credited with the next step in the development of centrifugal casting. His patents, taken out in 1848, cover a crude apparatus for rotating a two part mold and offer the first information as to how rotation of a mold was actually accomplished. The development of his method was carried forward in England by Andrew Shanks sometimes credited with being the first inventor to utilize centrifugal force in casting. Shanks' patents are described in detail in the "Scientific American" for December 1, 1849, and it is interesting to note that the object of the method, as stated in the patent, was to do away with cores and to insure uniform thickness. The patent covers a horizontal machine for casting tubes as well as a machine for vertical rotation to cast vessels. The Shanks process was originally based on heating the molds "to prevent the iron from setting too rapidly." This invention deserves more than passing notice as the processes described were actually used in the production of pipe and sheets. Records indicate that in 1852 cast iron gas pipes, 3 in. in diameter and 12 ft. long, were being made by Shanks and, at the same time, iron cylinders were being cast which were cut apart and flattened out to form sheets.[2]

The theory of the effect of rotation around two axes suggested by Eckhart was again covered by Peters in his machine patented in 1855. Unfortunately, mechanical difficulties in obtaining the desired rotation prevented the inventor from accomplishing satisfactory results.[1]

The German authority, Prof. Enst Sewicki, credits the English engineer, Johnson, with the method of casting steel wheels.[3] Other authorities claim that the method described in his patents had been perfected some year previously by a Frenchman, Dumery, and was at that time actually in use in France. This latter method was undoubtedly ingenious and consisted of placing the body of the wheel with a very thin rim in a chill and, after bringing the rim up to the fusing temperature, rotating the mold and pouring the annular ring outside the rim full of molten metal. This method was actually used for some time in the foundries of Jackson, Petin and Gaudet.[1]

The year 1859 was one of remarkable advance in the art of centrifugal casting. It was at this time that Sir Henry Bessemer perfected a method for casting bars, plates and rods of malleable iron or steel from which the gases had been removed by centrifugal force. M. Tresca, in a discussion before the Institution of Mechanical Engineers in 1867, refers to rails manufactured at the Imphy Iron Works by this method as "remarkably free from blow holes."[4] Some years later the Commentary Fourchambault Company tried casting ingots for rail rolling in molds placed about a center axis like spokes of a wheel. For short ingots this method gave good results which, unfortunately, were not duplicated with larger ingots.[5]

The Bessemer patents refer specifically to the possibility of varying the metal during pouring, so as to give successive layers of different metals. By this method better results were obtained than Johnson had been able to obtain by allowing one casting to cool before the second layer was superimposed on it. We find that several inventors were impressed with the advantage of casting dissimilar metals together. Just at this time A. A. Needham of Rockford, Ill., proposed a similar method of casting car wheels and the French patent of M. Grand for combining tin and lead was based on the same theory. Professor Sewicki claims that credit for this invention should be given to Huth and there seems to be some basis for his claim in that the Huth process was actually in service at the time his article was written.[1]

During the same year (1859) Freeborn Adams inauguarted the idea of casting copper tubes in a vertical mold. For short tubes this method was satisfactory, but with longer sections it was necessary to use cores to prevent the parabolic action resulting from the combination of rotative force with gravity.[1]

No discussion of centrifugal casting would be complete without considering the work of Joseph Whitley of Leeds, England, whose patents cover the period between 1860 and 1885. Working alone, or in conjunction with other engineers, he perfected many

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*Research engineer, United States Cast Iron Pipe & Foundry Company, Burlington, N. J.

ideas which, although they have not in themselves been commercially successful, have aided other inventors in solving their problems and have been studied in connection with many of the more recent inventions. It has been said of Whitley that he had a "keen appreciation of the controlling influences * * of cetrifugal castings."[6]

One of his early patents, taken out in conjunction with Bower, covers a machine for casting iron wheel tires. The patent refers to a mold coated with clay into which iron was poured or a pasty wrought iron bloom was forced. The force of rotation causes the metal to assume the form of the mold. It is evident that the process was not always successful as the patent provides that if the result was not satisfactory, the tire "could be reheated and rolled, hammered or pressed to size."[7]

Many of his patents covered methods of distributing the molten metal in the mold. The first investigation of this type was made with Sampson Fox and resulted in a bottom pour ladle mounted on wheels so that it could be run into the mold. Holes were placed at regular intervals along the bottom so that the iron was delivered in a number of streams so as to prevent cold laps and uneven thickness.[8] An interesting development of this pouring ladle consists of a trough designed with a series of spouts at regular 6 in. intervals throughout its length. As this trough is tipped, iron is fed into the mold at several points.[9] This pouring device has a reciprocating motion of 3 in. so that during pouring the metal is fed in with a weaving motion giving the effect of a woven fabric. This patent also covered the introduction of compressed air into the mold to neutralize "the vacuum caused by the great heat in the respective molds." This vacuum, they claimed, resulted in iron with "drawn and blown holes."[8]

The next important patent was taken out by Whitley, working independently. He suggested the use of a heat resisting packing as a mold lining to conserve the heat in the casting and give greater density and tensile strength. Several subsequent patents apply to this idea but apparently Whitley was not successful in departing from the permanent molds in use at that time. This inventor also suggested the idea of weighing the metal before pouring to control the thickness of the casting, as well as a method of removing the casting from the mold by means of a screw.[8]

One of the most interesting of the early inventions was that of Chalmers in 1867. He proposed to place pipe molds radially like the spokes of a wheel. In addition to the rotation of the molds around the central hub each individual mold rotated about its own axis. It was expected that this combined rotation would eliminate the need of cores.[1] There is no record that this method was successful, but the idea of similar molds mounted on opposite sides of an axis is used today to form intricate castings.

Thompson made use of his patent, dated 1873, to produce lead sheets by the centrifugal method. A cylindrical mold rotating horizontally was used, and, after the molten lead had set in the form of a cylinder, it was cut longitudinally and flattened out. Reference has been made to the uniformity in thickness and freedom from defects of sheets cast in this way.[8] Almost the same year, C. W. Torr combined the researches of other inventors and patented a process for casting tubes in a rotating horizontal mold. His machine was designed for casting long pipes of non-ferrous metals.[1]

Years of investigation were beginning to bring results and in the Journal of the Iron and Steel Institute for 1882 we find a reference by F. W. Webb of Crewe to locomotive drive wheels cast by centrifugal force. The writer referred to the "sound clean wheels" which resulted from this method of casting. Today it seems remarkable that the results were satisfactory as the rotation was held down to 40 or 50 rpm.

Professor Sewicki refers to G. Höper as the first inventor to consider the shape of the spout for carrying metal into the mold. His patents, dated 1890, cover also the casting of metal into spiral molds which were later drawn unto wires. Shortly afterwards, E. P. Förster of Berlin worked out some developments of the original Shanks' patents. He made use of a spout which could be drawn from the mold. The methods suggested were too complicated to be practical, but the principles evolved were of value in the later development of the art of centrifugal casting.[3]

The problem of introducing the molten metal into the horizontal mold without splashing has been given much attention by engineers. In 1891, Lane suggested that the iron be introduced into the mold in a narrow stream to which had been imparted a rotary motion. As the mold is being poured it is gradually withdrawn so that the metal is deposited continuously over the entire surface of the mold.[9]

Centrifugal force was utilized commercially late in the nineteenth century to eliminate blow holes in steel ingots for rolling. Credit for the development of this process is due to J. L. Sebenius of the Nykroppa Steel Works (Sweden). The process was simple. Two molds were suspended on a yoke and on opposite sides of the hub. These were filled with steel and the machine rotated. Centrifugal force caused the swinging molds to assume a horizontal position and at the same time forced the impurities and gases out of the steel.[10] Several installations were made in the various plants of the company mentioned and they were operated for a number of years. Unfortunately, the method was not adaptable for use with large ingots and since the death of the inventor the method has been abandoned.[5]

Many great engineers have tried to solve the difficulties of centrifugal casting and in 1895 we add the name of Sir Hiram Maxim to the list. The plan of this inventor was to make pipes in a continuous length by centrifugal force. Metal was fed into a rotating mold tapered towards the feeding end so that the liquid metal pressed the molded pipe forward in front of it. At the end of the mold the pipe was cooled by a water jacket and was solidified sufficiently to pull out onto rollers.[8]

The nineteenth century closed with most of the elemental research on centrifugal casting completed. However, there were many minor problems as yet unsolved and a review of the first six months of 1900 discloses five patents granted on centrifugal casting machines. Among these patents is a horizontal casting machine invented by Ferdinand Deming of Waterbury, Conn. This machine is equipped with pistons, one of which blocks off the mold until the proper time when the molten metal is admitted as a body. The other piston serves to remove the ingot after pouring.[1]

Several inventors have tried to make use of the fact that metal cast centrifugally around a vertical or

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inclined axis assumes the form of a parabola. Taylor and Wailes in their English patent, dated 1878, refer to the "ring-shaped section of a paraboloid of revolution" assumed on rotation around a vertical axis. The same phenomenon is referred to by Davies (1870), Huth (1895), and Stridsberg (1900). Theoretically, at least, this parabolic action could be used to form castings of a desired shape and it has been used for casting hollow tapering brass tubes.[11]

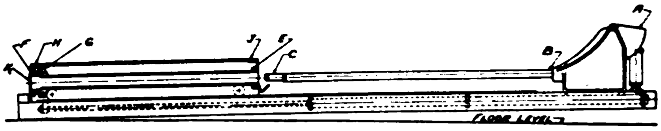
## The deLavaud Centrifugal Process of Casting Pipe

The first centrifugal process to be used for the commercial production of heavy ferrous castings on a large scale was invented by Demitri Sensaud deLavaud. Convinced that many of the difficulties of centrifugal casting were due to the molds used by the early inventors, deLavaud started in 1914 a series of experiments on casting pipe in parmanent rotary molds. Heated molds were first used without success, as it was impossible to withdraw the pipe for at least three minutes after pouring. After experimenting with molds heated to various temperatures, it was decided to try a cold mold. The inventor had to pour the pipe himself as his foundrymen were afraid of the action of the hot metal on the cold mold. The first pipe cast in this way was satisfactory and could be withdrawn in a few seconds after poring. No provision for cooling the mold had been made and as operation continued and the mold gradually heated it became increasingly difficult to withdraw the pipe, indicating that hot molds caused the earlier troubles.[12] As a result of these experiments, principles were developed which have since been followed in the commercial production of centrifugal castings.

After devoting two years to further development of this process, deLavaud had a machine built in Buffalo with a view to introducing the process into the United States. He was not immediately successful in convincing foundrymen in this country that their problems were solved, but in 1917 the National Iron Works, Ltd., of Toronto, took over the rights of Canada.[13] Commercial production was started almost immediately in their foundries and the plant has operated continuously up to the present time. Shortly after this the Centrifugal Cast Iron Pipe Company and the International deLavaud Manufacturing Corporation, Ltd., were organized to control the development of this process.

In 1921 the United States Cast Iron Pipe and Foundry Company obtained the rights for the deLavaud process for making pipe in this country and experimental work was immediately started at their Burlington Works, Burlington, N. J. The development of the process on a commecial basis proceeded rapidly and early in the next year construction of a battery of four machines was started at their Birmingham Plant.[14] This plant was put in commercial operation in the fall of 1922 and the process proved so successful that the battery was duplicated shortly after that time. Since then a second plant has been built at Burlington. This plant now comprises nine machines which is actually half the expected ultimate capacity.[15]

The deLavaud process for casting pipe centrifugally is essentially simple. Each unit consists of four parts. At one end of the machine is a pouring basin or tilting ladle (A) designed to feed the iron into the mold at a predetermined and constant rate. From the pouring basin the iron is conveyed into the mold by means of a spout (BC) long enough to reach to the extreme end of the mold. The end of the spout (C) is turned at an angle so that the molten iron flows into the mold in the plane of rotation. The entire machine is set at a slight angle with the horizontal so as to cause the iron to flow down the spout. This angle is too slight, however, for the action of gravity to effect the distribution of the iron once it is in the rotating mold.



deLavaud machine for centrifugal casting.

The mold (EF) itself is of steel and its inner surface is just the contour of the outside of the pipe. A motor or a water wheel (G) serves to rotate the mold in its casing (HJ). The annular space between the mold and the casing is filled with the cooling medium which keeps the mold at a constant temperature. In addition to the rotation of the mold, the mold and casing have a horizontal traverse slightly greater than the length of the pipe. This permits the distribution of the iron in the mold.

In actual operation the end of the mold away from the pouring basin is first blocked off with a stop plate (K). On this plate is the core for forming the lead space in the bell of the pipe. This is the only core in the operation and is needed to form the enlarged interior diameter of the pipe at this point; for pipe having a uniform inside diameter such as plain end pipe or flange pipe no core is necessary.

After this step the pouring basin is charged with enough iron to form one pipe. The mold is then advanced until the spout extends nearly through the mold so that the iron flowing out of the end of the spout will enter the bell cavity. With the mold rotating at a speed of approximately 600 rpm. (for a 6-in. pipe) pouring is started. As stated above, the iron flows as nearly as possible into the plane of the rotating mold and centrifugal force holds it against the inner surface of the mold. As soon as the molten iron fills the bell cavity the horizontal travel of the mold is again started; this time, however, it travels away from the pouring basin. In this way iron is fed into each part successively and the pipe is built up throughout its length. The surface of deLavaud pipe shows some evidence of the spiral ribbon of metal from which it is built up, but so rapid is the pouring that there is no evidence of segregations in the metal itself.

At the end of the horizontal travel of the mold, the spout is beyond the end of the pipe and any excess metal flows into a pig basin at the side of the machine from which it is later reclaimed. The entire complished by placing tongs in the bell end of the pouring operation takes only a few seconds and the pipe may be immediately withdrawn. This is ac- pipe and again advancing the mold allowing the pipe to roll out on skids.

The short time the pipe is in the cool mold produces only a surface chill and minor casting strains which are removed by placing the pipe in an annealing oven. After bringing the pipe well up towards its critical temperature it is allowed to cool slowly as it rolls through the oven. The idea of annealing cast iron pipe is not a new one and pipe cast by the older methods were required by specifications to be allowed to "soak" in the mold until they had lost the "color of heat."

### Effect of the deLavaud Process on the Iron

The deLavaud process was developed essentially to give a method of economically casting pipe of uniform section. However, the force under which deLavaud pipes are cast, as well as the action of the cold mold and subsequent annealing, improves the physical properties and microstructure of the iron to a marked degree.

The iron used in the process is the same as that used in making sand cast pipe. Test bars were poured from this iron before it entered the centrifugal machine. An average of nine bars, each 2 in. x 1 in. in section, placed flat and supported on 24 in. centers loaded at the middle supported a load of 2087 lbs. with a deflection of 36 in.[16]

After being cast into pipe by the deLavaud method, transverse test bars were cut from the walls. These bars were ¼ in. x ½ in. in section and were supported on 11½ in. centers. Each of the bars tested failed between 225 and 250 lbs. load. These tests indicate an increase of strength of 65 per cent, as shown by the $M_r$ of 37,000 lbs. per sq. in. for the first bars and $M_r$ of 62,000 lbs. per sq. in for the bars after centrifugal casting. Tensile bars cut from these test sections show similar results. The untreated iron had an average tensile strength of 20,242 lbs. per sq. in. compared with 36,658 lbs. per sq. in. for bars cut from the completed pipe.

In considering these tests it should be borne in mind that the strongest part of the deLavaud metal, i.e., the outer layer, has been removed by machining. For this reason actual bursting tests on the deLavaud pipe are far more indicative of its true strength. Full 12 ft. lengths of pipe were tested. The bell end was threaded and a threaded cap was screwed in place; the spigot end was closed by means of a stuffing box held in place in the regular foundry test press. This type of testing apparatus limits the stresses in the pipe to those imposed by the internal test pressure.

STRENGTH OF PIPE

| | Average Minimum Wall Thickness Inches | Average Bursting Pressure lbs. per sq. in. | Average Tensile Strength lbs. per sq. in. |
|---|---|---|---|
| 6-in. Sand Cast Pipe.... | 0.50 | 2475 | 14,600 |
| 6-in. deLavaud Pipe...... | 0.39 | 3730 | 29,200 |

As a result of an independent investigation, Professor Gillespie of Toronto University summarized the change in physical properties resulting from the deLavaud process by stating "the strength in tension and cross-bending, the resistance to shock and the stiffness are about twice as great for machine made iron as for the sand cast product."[17]

As long ago as 1840, Robert Mallet in "An Extensive Study of the Corrosion of Metals" made for the British Society of Civil Engineers stated that of two metals having approximately the same chemical composition the denser would resist corrosion to a greater extent. That the finer grain of deLavaud pipe is corrosion resisting has been brought out by the soil corrosion tests now being conducted by the National Bureau of Standards.[18] This is probably due to some extent to the uniformity of deLavaud metal and its freedom from impurities. It is estimated that the force available for the elimination of gas and impurities is thirty-two times as great for a 6-in. pipe cast centrifugally as for the same pipe made by the old sand cast method.

DeLavaud pipe fulfills the expectations of the inventor in that it is remarkably uniform in thickness. Variation of thicknesses average under 0.02 in. throughout the circumference. When we consider that sand cast pipe often varies as much as 0.12 in. circumferentially the accuracy of deLavaud pipe becomes more remarkable.[19]

DeLavaud's hope for economy has also been fulfilled and pipe cast by this method is sold at a lower cost per foot than the heavier sand cast pipe. This saving has been made possible, however, by numerous improvements in the details of the process itself. In 1919, the plant at Toronto was turning out 15 pipes in an hour; today the regular output is more than double this figure for 6-in. pipe. Obviously the process is no longer in the experimental stage and there are now many thousand miles of deLavaud pipe in sizes from 4 in. to 20 in. giving satisfactory service here and abroad.

At present there are eight companies operating under the deLavaud patents for making cast iron pipe:

The United States Cast Iron Pipe & Foundry Company—plants at Birmingham, Ala., and Burlington, N. J.

The National Cast Iron Pipe Company (sublicensees of the above company)—plant at Birmingham, Ala.

The Stanton Iron Works Company, Ltd.—plant at Stanton, England.

Tsuda & Company—plant at Osaka, Japan.

The National Iron Corporation, Ltd.—plant at Toronto, Canada.

Compagnie Generale des Conduites d'Eau—plant at Liege, Belgium.

Hoskins Iron & Steel Company, Ltd.—plants at Sidney and Lithgow, Australia.

Gelsenkirchener Bergwerke—plant at Gelsenkirchen, Germany.

### Other Centrifugal Processes

Recently there has been developed a method of casting pipe by centrifugal force known as the "Sand-Spun" or "Mono-Cast" process. This differs in several essentials from the deLavaud process. An individual sand-lined mold is used for each pipe and the iron is introduced while the mold is warm, the full charge of molten metal to form the pipe being poured into the tilted mold. The mold is then rotated and as the desired speed for casting is approached the mold gradually assumes a horizontal position. This process is now being used commercially by R. D. Wood Company of Florence, N. J., and the American Cast Iron Pipe Company of Birmingham, Ala.[20]

The Hurst-Ball system of centrifugal casting is now in use in the foundries of Centrifugal Castings, Ltd., of Kilmarnock, Scotland.[9] Originally the use of this system was limited to short cylinders of rather large diameters such as piston rings, engine cylinder liners, wheels and roll castings from 10 in. to 30 in. in diameter and up to 36 in. in length. The process makes use of hot steel molds kept up to the required temperature by turning out the castings in rapid succession. It was impractical for use in making long tubes of small diameters as contraction on cooling such tubes was so slight that they must be allowed to cool quite materially before being withdrawn.[21] Through the development of a pouring spout, somewhat similar to that of Whitley described previously, cast iron pipe 36 in. in diameter and 12 ft. long have been produced. This device consists of a tilting pouring spout equipped with a helical weir edge approximately the length of the casting to be produced. The iron is fed into the mold by partially tilting the spout which feeds the iron continuously, starting at one end of the pipe and ending at the other.

One of the most recent of the various methods of casting pipe centrifugally is the Henry-Weitling-Peake process. In this method the mold is kept at the correct temperature by circulating hot mercury vapor under pressure around the mold. The patent includes provisions for retaining the mercury which may be used continuously. Another patent controlled by this company covers the use of permanent bell cores of gas carbon as well as the use of carbonaceous linings of the mold.[22]

For a number of years Stokes Castings, Ltd., of Mansfield, England, has been making castings centrifugally and their work has been taken over recently by the Sheepsbridge Stokes Centrifugal Castings Company, Ltd.[23] The Stokes process makes use of permanent molds heated from the castings. Various types of rings and cylinder linings are made by this process.[24]

Centrifugal casting is the ideal method for casting piston rings and in addition to this application of the Stokes and the Hurst-Ball systems there are several others in use. The interest that manufacturers take in this seemingly small product may be realized when we consider that the Ford Interests alone use 16,000,000 rings each year. One foundry makes use of the deLavaud process for casting rings with only slight modifications from the method described for casting pipe.[25]

In direct contrast with the method of casting rings in cold metal molds is that used by the Wasson Piston Ring Company, Plainfield, N. J. The rings made by the Wasson method are surrounded on three sides by sand during casting. In addition, the rotation is vertical, the iron being poured into the center of a dry sand mold representing four rings connected by gates. Piston rings in almost all sizes are now being made by this method.[26] The British Piston Ring Company, Ltd., of Coventry, England, casts piston ring pots centrifugally. From these pots the individual rings are subsequently cut.

For some years, castings of odd designs have been produced centrifugally. This has been accomplished by placing molds of similar volume on opposite sides of a vertical axis and rotating them. As a result of centrifugal force the iron fills the most intricate mold and the impressions are sharply reproduced. In addition the castings are remarkably free from impurities. Experiments made on castings of this type, but of non-ferrous metals, have been carried on for some time and it is hoped that the process will be developed commercially in the near future.[27]

In his paper on "The Development of the Centrifugal Process in Great Britain" before the American Foundrymen's Association late in 1926, J. E. Hurst stated that "the development of the application of the centrifugal process to the production of castings in steel has not been so extensive as in the case of cast iron." He refers to the Davis Steel Wheel process as the only application of importance in England. This process is used by John Brown & Company of Sheffield to secure a manganese steel rim on wheels.

In this country, as well as in England, most of the work on the application of centrifugal processes to use with steel has been of an experimental nature. A method of casting steel pipe in hot molds has been given much attention and one process has already been patented. The same inventor, Leon Cammen, has patented a method of casting steel ingots and plates centrifugally. His process makes use of a "bottle neck" mold to eliminate splashing.[28]

The McConway & Torley Company operating under the McConwey patents casts disk-shaped ingots in permanent molds. The feature of this process is that the metal is placed under pressure of 550 lbs. per sq. in. by means of a hydraulic piston as the metal sets. This, it is claimed, forces all impurities and gases through the pouring hole in the center of the mold.[29] Steel tubes and ring-shaped ingots have been produced in this country under the Milspaugh patents. Castings of this kind were used in the exhaustive investigation of centrifugally cast steel made by George K. Burgess of the Bureau of Standards.[30]

As is the case with steel, non-ferrous alloys are melted in "batches" and, therefore, it is difficult to have available a continuous supply of molten metal such as is desirable for centrifugal casting processes. Yet, in spite of this handicap, centrifugal processes are in use in other industries. The difficulty of producing perfect brass and bronze tubes by ordinary methods has long been recognized. Since 1918 experimental work on the development of a centrifugal method for casting such tubes has been under way.

Centrifugal force has also been used to produce aluminum and monel metal tubes, copper bands and large cast iron paper rolls. Unusual applications of centrifugal casting include the manufacture of concrete pipe, the casting of babbitt bearing and the application of wax coatings to the outside of paper rolls.

Professor Sewicki, the first authority to write exhaustively on centrifugal castings, listed the objects of this process as follows:[3]

1—To produce dense castings, free from blow holes and as a result having greater strength.

2—The elimination of the use of a core resulting in economy of operation.

3—To fill the molds completely and insure sharp outlines in the castings.

4—To influence the chemical changes in the metal during casting.

5—To make possible the combination of two or more metals in a casting.

It is interesting in considering the various processes described to note how successfully each of the methods attains one or more of these objects.

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## Papers to Be Read Before American Society for Steel Treating Convention

(Continued from page 375)

### Wednesday Afternoon

Joint meeting with Institute of Metals Division of American Institute of Mining and Metallurgical Engineers.

"Production of Single Crystals"—J. A. M. Van Liempt.

"Quantitative Spectrum Analysis"—F. Twyman and D. M. Smith.

"Monel Metal and Nickel"—C. A. Crawford.

### Thursday Morning, September 22

"Significance of Physical Properties of Steel Determined at Elevated Temperatures"—F. B. Foley, Midvale Company, Nicetown, Philadelphia.

"Wear of Plug Gages"—H. J. French and H. K. Herschman, Bureau of Standards, Washington, D. C.

"What Happens When High Speed Steel Is Quenched"—B. H. DeLong and F. R. Palmer, Carpenter Steel Company, Reading, Pa.

"Plastic Deformation of Metallic Crystals"—T. A. Wilson and S. L. Hoyt, General Electric Company, Schenectady, N. Y.

"Expansion Properties of High Nickel Steels"—Howard Scott, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

### Thursday Afternoon

"Determination of the Heterogeneous Field in Iron Nickel Alloys"—Dr. Kotaro Honda and Sansaku Muira, Tohoku Imperial University, Sendai, Japan.

"Ball Bearing Steels"—Dr. Bengt Kjerrman, S.K.F. Industries, Gothenburg, Sweden.

"Physical Properties and Structure, Longitudinally and Transversely, of Heat Treated Chromium-Molybdenum Sheet of Various Sizes—R. R. Moore and F. T. Sisco, Wright Field, Dayton, Ohio.

"X-Rays and the Constituents of High Alloy Steel"—E. C. Bain, Union Carbide & Carbon Research Laboratory, Long Island City, N. Y.

"Economic Use of Nickel Chromium Alloys in Gray Iron"—D. M. Houston, International Nickel Company, New York City.

"Uses of Stainless Iron in the Manufacture of Nitric Acid Plants"—W. M. Mitchell, Central Alloy Corporation, Canton, Ohio.

### Friday Morning, September 23

"Design from the Heat Treating Standpoint"—G. M. Eaton, Molybdenum Corporation of America, Pittsburgh.

"Forging Machine Die Practice"—E. R. Frost, National Machinery Company, Tiffin, Ohio.

"High Temperature Treatment of Castings and Forgings"—W. J. Merten, Westinghouse Electric & Mfg. Company, East Pittsburgh, Pa.

"Special Heat Treating of High Carbon Steel for Cold Forming Dies"—F. L. Wright, Atlas Ball Company, Philadelphia.

"Locomotive Forging Steels"—O. V. Green, Reading Company, Reading, Pa.

### Friday Afternoon

"Comparison of Brinell, Rockwell and Scleroscope Tests"—R. R. Moore, Wright Field, Dayton, Ohio.

"Refractories and Abrasives"—H. F. Beecher, Norton Company, Worcester, Mass.

"Machinability of Metals"—O. W. Boston, University of Michigan, Ann Arbor, Mich.

"High Speed Diffraction, Using High Voltage Radiations"—Dr. Ancel St. John, New York.

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## Welding Plant at Capacity

The Williams Welding and Manufacturing Company of Charleroi, Pa., are working at capacity production. This company manufactures water cooled doors and door frames, for open hearth and furnaces of a similar type. The doors and frames are formed of welded steel plates.

# The Use of Metallurgical Limestone*

### A Clear Explanation of the Function of Limestone in the Blast and Open-Hearth Furnaces. Its Properties, with Emphasis on the Impurities, Given Attention

By **OLIVER BOWLES**†

IT is a fortunate circumstance that limestone deposits are widely distributed in the United States. Every state has deposits. On account of lack of the desired chemical or physical properties, or difficulties of quarry operation or rock transportation, large tonnages of metallurgical stone are transported for long distances.

Naturally the widest development has been near the centers of the great smelting industries. Thus the Eastern Ohio and Western Pennsylvania quarries supply enormous quantities of limestone for the smelting districts lying in and about Cleveland, Ashtabula, Youngstown and Pittsburgh. The growth of great iron smelting industries at lake ports, such as Chicago, Cleveland and Buffalo, is due in part to cheap water transportation of the ores from the Lake Superior district, and in part to the same ease in transportation of fluxing stone. The accessibility of the iron ranges to the Great Lakes has its counterpart in a lesser degree in the development of a great limestone industry in the Northern Peninsula of Michigan near Alpena and Calcite, where the largest quarries in the world are now operated, producing thousands of tons of stone every day. It is noteworthy that the low cost of water haulage permits transportation for many hundreds of miles, while rail haulage for similar distances would be economically impossible.

## Production Statistics

Following is a list of the chief flux-producing states with their tonnages based on 1925 figures compiled by the Bureau of Mines:

**FLUXING STONE PRODUCTION IN SHORT TONS IN THE LEADING STATES**

| State | Short tons |
|---|---|
| Pennsylvania | 8,465,170 |
| Michigan | 6,054,270 |
| Ohio | 2,917,380 |
| West Virginia | 2,208,220 |
| Alabama | 889,840 |
| Illinois | 710,130 |
| Colorado | 355,060 |
| Utah | 207,140 |
| All other states | 1,033,290 |
| Total | 22,840,500 |

## Purpose and Action of Blast-Furnace Flux

Most iron ores carry silica and alumina as impurities, and the addition of a basic flux such as limestone is necessary to form a slag with them.

Lime is infusible at the temperature of a blast furnace, but when it combines with the silica and alumina of the ore and the ash of the coke it forms a liquid slag which floats on the molten iron. Thus the molten iron, freed in large measure of these impurities, is tapped off from beneath while the slag is drawn off separately and removed to the slag dump.

Another purpose of the flux is to remove the sulphur from the charge, for this element is a serious impurity in iron and steel. Thus an important function of fluxes is to provide materials that have greater affinity for such an impurity than the impurity has for the iron, steel or other metals. Normally the slag removes about 85 per cent of the sulphur entering the furnace.

Lime is regarded as a better desulphurization agent than magnesia. Lime has a greater affinity for silica than it has for sulphur, hence it forms calcium silicates until the silica is exhausted, after which it reacts with the sulphur to form calcium sulphide. It is important, therefore, to have present an excess of lime above that required to combine with the silica. For the most effective reaction a high temperature should be maintained, for at high temperatures the slag will more completely desulphurize iron than at low temperatures. This is due to increase rates of interchange between slag and metal at the higher temperature, and to the fact that a more basic slag can be carried. Sulphur and other impurities are best removed where the slag has a high fluidity.

Some ores are associated with sufficient lime to be self-fluxing. Ores are said to be self-fluxing when the sum of the calcium and magnesium oxides is approximately equal to the sum of the silica and alumina. Such ores occur in the iron district of Birmingham, Ala. They melt very readily as the constituents are intimately mixed.

## Effect of Impurities on Fluxing Stone

The majority of blast furnaces employ about 900 lbs. of flux for each long ton of pig iron produced. The amount of flux required varies with the amount and nature of the impurities in the ore and in the stone itself. The foreign elements in fluxing stone are usually the same as those in the ore for the removal of which the flux is added, namely, silica and alumina. It should be emphasized that impurities in the limestone are doubly detrimental; in the first place their presence reduces the percentage of lime and magnesia in the stone, and in the second place they require a certain share of the lime and magnesia to flux them off, as the flux must neutralize its own impurities as well as those of the ore.

"Available carbonate" is a term applied to the percentage of calcium and magnesium carbonates available for fluxing the ore after a sufficient percentage has been deducted to neutralize the impurities in the stone itself. In the average blast-furnace slag the ratio of $SiO_2 + Al_2O_3$ to $CaO + MgO$ is about 1 to 1. Thus for every pound of silica and alumina present in a high calcium flux, a pound of lime is required to flux it. A pound of lime ($CaO$) is derived from 1.785 lbs. of limestone ($CaCO_3$3). Hence if there are 4 lbs. of $SiO_2 + Al_2O_3$ in each 100 lbs. of the stone, not only does the stone lose this 4 lbs. of impurity, but also 4 × 1.785 lbs. of pure limestone which are required to flux the impurity, that is a total of 11.14 lbs., and the "available" carbonate in each 100 lbs. of stone is only 88.86 lbs. This may be expressed in a general formula as follows: If A = the percentage of $SiO_2 + Al_2O_3$ in the stone, then the available carbonate is 100 — A — 1.785A, or 100 — 2.785A. Where a dolomite is employed it requires about 1.914 lbs. of stone to give 1 lb. of the combined oxides of calcium and magnesium. Hence for a dolomite flux the general formula for determination of available carbonate becomes 100 — 2.914A. Most fluxing stone used in the United States runs under 10 per cent magnesium carbonate, and hence the conversion factor may be taken as 1.8 and the general formula 100 — 2.8A.

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*Circular No. 6041, Bureau of Mines.

†Superintendent, Nonmetallic Minerals Experiment Station, Bureau of Mines, New Brunswick, N. J.

The presence of impurities has other disadvantages. It has been noted above that a certain percentage of the oxides liberated from the carbonates in the stone unites with the silica and alumina in the stone to form a slag. It is evident that the fluxing of these materials will require fuel, therefore, the fluxing of the impurities in the stone requires additional coke above that required for fluxing the silica and alumina in the ore. Extra slag requires extra coke, but there is a difference of opinion as to how much extra coke is needed. As other conditions may affect the amount of coke required for each additional pound of slag formed, it is difficult to arrive at an actual figure for the additional fuel cost when an impure stone is used. If A = the sum of silica and alumina in the stone, the slag formed from these impurities will be approximately 2A. If it is assumed that "x" pounds of coke are required for each pound of slag, then the extra coke required to flux the impurities in the stone will be 2Ax lbs. for each 100 lbs. of stone. Hence, any blast-furnace operator who has determined a figure for the amount of coke required for each additional pound of slag formed, can estimate closely the additional fuel expense due to the use of impure stone. Assuming a value of y cents per ton for metallurgical coke, the extra cost of fuel on account of impurities in the stone will be

$$\frac{2Axy}{2000} \text{ or } \frac{Axy}{1000}$$

cents for each 100 lbs. of stone. For each ton of stone this will be

$$\frac{20Axy}{1000} \text{ or } \frac{Axy}{50} \text{ cents.}$$

A third source of loss due to impurities in the stone is reduced furnace output. Furnace output for a given ore is in general inversely proportional to coke consumption per unit of slag, and as the extra slag requires extra coke furnace production is cut down to some extent.

If V = the price in cents of pure stone per ton, and V′ = the price of impure stone, then, disregarding the possible reduction in furnace output and combining the two chief sources of loss, namely the reduction in available carbonate and the extra fuel required,

$$V' = V(1 - .028A) - \frac{Axy}{50}.$$

**By substituting any given values for percentages of impurities, pounds of coke per pound of slag, and value of coke per ton, a fairly definite figure may be** obtained for the value of an impure stone as compared with a pure stone. If the value of an impure stone as thus calculated is lower than the actual cost at which such stone may be delivered at the furnace, it would not pay to use the impure stone.

Other impurities in the stone are sulphur and phosphorus. Usually they are present in amounts so small as to be negligible. A sulphur content of less than 0.1 per cent does no harm, and it is unusual to find more than this amount in commercial limestone. Phosphorus is usually deleterious only where the flux is used in the manufacture of Bessemer iron. Where so used the phosphorus content should be as low as possible, and should not exceed 0.01 per cent. For other grades of iron the phosphorus content may reach 0.1 per cent without harmful results, and a content as high as this is exceedingly rare.

The effect of magnesia in fluxing stone is an unsettled question. Some furnace men are opposed to magnesium while others use magnesian stone successfully. Dolomite is widely used as a blast furnace flux in England. As a rule high-calcium fluxes are preferred if they are readily attainable, but the difference in action between the high-calcium and the fluxes is so small that usually the choice is governed by other factors such as cost or percentage of impurities. For example, at some of the Alabama furnaces dolomite is preferred, not because of any preference for magnesia, but because the dolomite has a lower silica content (1.25 per cent as against 3.5 per cent in the high-calcium stone) and also because of a greater uniformity in the composition of the dolomite. The subject of magnesia is discussed more fully in a subsequent section.

## Factors Governing Use of Impure Fluxing Stone

The cost of stone delivered at the furnace commonly has a very direct bearing on the quality of stone used. This is due to the fact that an inferior stone may be used if the price is low enough. The question of quality is so intimately related to cost that the problem of purity of blast-furnace flux becomes quite complex. In order to clarify this point, it is necessary to make a distinction between impurities. In general they fall in two classes. Some, such as sulphur and phosphorus, are detrimental to the quality of the iron produced, hence the use of stone containing excessive quantities of these impurities could not be justified no matter how low the price. The other more common and abundant impurities are silica and alumina, and they are not regarded as detrimental to the iron, their chief disadvantages, as pointed out previously, being the requirement of additional limestone and coke to convert them into slag. Suppose that a relatively pure stone and an impure stone are both available, and that the impurities are of the silica-alumina type which has no detrimental effect on the iron. If the price of the impure stone is low enough to overcome the disadvantages then the impure stone may be used in preference to the pure stone. Thus at Bethlehem, Pa., a stone quarried near the furnaces, running as high as 5 per cent silica is used extensively in preference to the low-silica stone from McAfee, N. J., because the transportation charge from McAfee is greater than the total cost of quarrying the impure stone. The quality of the ore also influences the degree of impurity permissible in the flux. **Thus it would not be wise to use a flux high in silica with a high silica ore.**

It is evident from the above that no definite rules can be laid down regarding the purity of a stone that may be used for flux. A stone that might be condemned in one locality, might be quite acceptable in another where the conditions were different. The direct bearing of cost on use indicates how important it is to be able to calculate even approximately the relation between percentage of impurities and price, as discussed previously. Ususally the use of an impure stone can be justified only where it has the advantage of close proximity to the furnace, thus eliminating the usually heavy item of transportation expense.

### Size of Stone for Blast-Furnace Flux

Fluxing stone is used in a great variety of sizes. At some furnaces the crusher run is used directly without screening. Usually the fines below ½ in. are taken out, partly because they tend to retard the draft, and partly because they usually contain more impurity than the lump stone, as sand and clay segregate in the fines. In modern quarry practice, and particularly in underground mining there is less impurity mixed with the stone than during former years under cruder practice; therefore, on the basis of purity, fine materials may not be detrimental. A common range in size is —4½ in., +½ in, though larger sizes are often used. Maccoun* claims that all stone should pass through a 6-in. ring, as large lumps may go unburned even to the tuyere, wasting heat, and injuring the furnace lining by corrosion. Blast-furnace troubles have been attributed in some instances to irregularities in size of the limestone used. In general it may be stated that uniform sizing improves the working of the furnace.

### Basic Open-Hearth Flux

The open-hearth process of making steel consists in melting pig iron and steel or iron scrap, and boiling the mixture generally with the addition of some very pure lump iron ore, until the carbon is reduced to the desired amount. A flux is added to the charge in the furnace mainly for the removal of phosphorus. For a phosphorus content in pig iron not exceeding 0.25 per cent, additions of 6 to 12 per cent limestone are considered good practice. When a pig iron with a higher phosphorus content is used as much as 17 per cent limestone may be charged. The phosphorus is oxidized to phosphoric acid which unites with the lime to form calcium phosphate. The ability of a slag to take up phosphorus depends both on basicity and fluidity. Fluorspar ($CaF_2$) is added because it increases the fluidity without decreasing the basicity. It is possible, however, to have the slag too fluid for it then becomes active in attacking the dolomite lining. The more basic the slag the higher its melting point; hence, the higher its temperature the more lime it can absorb. An excessively high temperature is also destructive to a dolomite lining as it may approach the softening point of the dolomite.

Either lime or limestone may be used. When the flux is added in carbonate form the evolution of $CO_2$ makes the bath boil, insuring a lively reaction. Extra heat is required for calculation, but evidently no more additional heat is needed than would be required for precalcination.

In blast-furnace slag the proportion of $CaO + MgO$ to $SiO_2 + Al_2O_3$ is about 1 to 1, but with basic open hearth slag this ratio is about 2.5 to 1. Hence if $A =$ the sum of $SiO_2$ and $Al_2O_3$ in the fluxing stone, the bases ($CaO + MgO$) necessary to form a slag with these impurities will be 2.5 A, and the carbonates required will be $1.8 \times 2.5A$. The formula for determination of available carbonate is therefore $100 - (1.8 \times 2.5\,A + A)$, or $100 - 5.5\,A$. In comparing this with the general formula for available carbonate in blast-furnace flux which reads $100 - 2.8\,A$, it is evident that impurities are much more detrimental in open-hearth than in blast-furnace flux. Thus a limestone with 2 per cent impurity when used as blast-furnace flux would have an available carbonate content of 94.4 per cent, while if used for basic open-hearth flux it would have only 89.0 per cent available carbonate. On this account specifications for open-hearth flux usually demand a limestone with a silica content not to exceed 1 per cent, and an alumina content not exceeding 1.5 per cent.

As the chief office of basic open-hearth flux is the removal of phosphorus, and as magnesium has a lower affinity than calcium for this element, dolomites or magnesian limestones are undesirable. The maximum permissible content of MgO is usually fixed at 5 per cent.

Where the blast furnace is operated in connection with a steel plant the open-hearth slag may be used as blast-furnace flux, for it provides both iron and flux. It may be used up to 10 per cent of the total ore burden.

The size of stone to be used in open-hearth steel furnaces depends to some extent on the rate of solution of the stone in the slag. Fragments of most well consolidated limestones retain their original shapes, and are more or less firm and solid after complete calcination. Lime burners desire stone of this quality for it gives a high percentage of lump lime. Therefore, after the limestone lumps in an open-hearth furnace are completely calcined, they may still retain their original shapes. Limestones vary greatly in the rate at which such masses of lime dissolve in the furnace charge, and obviously large masses of a slow-dissolving stone should not be used. No definite data have ever been assembled on the rate of solubility of various limestones in the open-hearth furnace.

It is noteworthy, therefore, that the adaptability of a stone for open-hearth flux depends on the rate of solution as well as on composition. A slow-dissolving stone may demand an unusually long time for the complete reaction to take place in the charge. Sometimes excessive fluorspar is added in an attempt to hasten the reaction, and this has the double disadvantage of wasting comparatively high-priced fluorspar, and of making the slag too liquid.

### Use of Dolomite as Furnace Lining

Magnesite ($MgCO_3$), dolomite ($CaCO_3$, $MgCO_3$), and dolomitic limestone are used for lining basic open-hearth furnaces. Dolomite is the most common. Usually it is precalcined before it is placed in the furnace. The dolomite should be low in impurities, for if impure lining is employed its softening temperature is lowered, and it is more easily attacked by a fluid slag. The raw material is crushed, calcined, mixed with a small amount of tar or molasses, and tamped in to a

(Continued on page 395)

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*Maccoun, A. E., "Recent Blast Furnace Advancement," Blast Furnace and Steel Plant, vol. 49, 1915, p. 67.

# Dodge Forge and Heat Treating Plant

## General Description of the Plant. Forge Shop Exemplifies Latest Practice in Design and Equipment. Heat Treating, Cleaning, and Pickling Performed on Large Production

By **CHARLES LONGENECKER**

FEW persons will dispute the standing of the Dodge car in the automobile world of today. That it stands among the foremost is largely to the credit of its progenitors, John F. and Horace Dodge. These men came to their task, that of manufacturing automobiles, fully prepared by years of experience. This they gained in the construction of parts for other cars, which had been placed on the market years before their first one had passed down the "run way."

Since the day when the first Dodge car was assembled there has been decided progress and improvement in practically every detail of automobile construction. Steel and other metals, of which the various parts are composed, are now of a higher quality and of a composition more suitable for the duty these parts perform. Plant practice is also better adapted to the shaping and finishing of the intricate mechanism entering into the modern car. And with these developments there has been a similar advance in the equipment placed in the shops, so that efficiency today is at a much higher standard than it was in former years.

A plant embodying these advanced features is that recently put in operation by the Dodge Motor Corporation, on the outskirts of the city of Detroit, consequently it has been selected as representative of modern practice.

Ground was first broken for this plant in the month of February, 1925 and in August of that year, the equipment was in place and ready for service.

A plan view of the various buildings constituting Plant No. 2, is shown in Fig. 1. Around these buildings ample space remains for any extensions that may be found desirable. Moreover, for the use of the company's employes, who come to and go from the plant in automobiles, a parking space has been layed out near the power plant. In this space 300 to 400 automobiles can be parked.

The buildings which make up the plant are: Power house, die shop, light hammer shop, heavy hammer shop, heavy hammer shop extension, heat treating building, rough grind building and pickling building.

The floor of each building is formed of paving brick layed in concrete and crowned to a height of 3 in. Around, and connecting the several shops, are concrete pavements or roadways, 15 ft. in width, while entrance to the plant is afforded by means of a main roadway about 20 ft. in width.

### Routing of Material

In locating the different shops, careful consideration was directed to the movement of finished and semi-finished material. As the daily output of the plant, in normal times, averages approximately 375 tons economic and expeditious handling of the product are vital factors. With this feature in mind each department was so located that the material produced in it is transported for further treatment, or disposal, directly toward the loading platform, from which it is carried into cars. This platform is at the side of the heat treat building. Thirteen 3-ton electric trucks furnish the motive power for the conveyance of the steel "tote" boxes in which all forgings, etc., are placed while for the transportation of dies, one high lift truck has been provided. In order to keep these trucks in repair, as well as to furnish a convenient garage where the batteries may be recharged, a service building was erected at one end of the die shop.

Between the several buildings, 45 ft. has been alloted for the storage of steel, which is received in cars from the steel mills and is unloaded by magnets carried on 10-ton cranes passing over the entire length of the stock yard. Each stock yard is divided into sections by means of 8 in. Bethlehem H sections, imbedded, upright, in a heavy concrete foundation. As the steel is needed it is sheared to the required length by one of five shears and, when properly cut to length, is carried to the hammers on the trucks.

### Fuel Supply and Distribution

Continuity of plant operation, in all forging and heat treating plants, is absolutely dependent upon an

View showing the shops in course of erection uninterrupted supply of fuel, not only for the creation of power, but also for the generation of heat in electric and metallurgical furnaces. Inasmuch as the boilers are fired with coal it is only requisite for these that a sufficient supply of this fuel be kept in stock, but for those furnaces burning fuel oil, besides an adequate storage, there must be insurance against suspension in distribution. Protection against such a mishap is provided by the installation of both steam and electric driven pumps with power connections from both plant and outside sources. Pumping capacity from both types of units alone is sufficient for every demand. For oil storage there are six tanks, of which number two have a capacity of 150,000 gallons each while the remaining four will hold a total of 50,000 gallons. Thus, when all tanks are full there will be a reserve large enough to sustain operations for 10 days. In order that the length of the oil distributing lines may be as short as possible the storage tanks and pumps have been so located that they are in position central to the shops to be supplied. In Fig. 1, the pump house is seen between the two 150,000 capacity tanks while the 12,500 gallon tanks are on the sides opposite.

The oil burned in the furnaces has a viscosity varying from 300 to 600. It is heated to a temperature of approximately 160 deg. F. by steam flowing through coils placed in the storage tanks, and by auxiliary steam heaters located along the distributing line. All oil piping in the building is suspended overhead, whereas outside the building it lies in tile with steam lines adjacent. The longest line extends a distance of 2,200 ft.; hence along this line two auxiliary heaters have been placed in order that the oil may be maintained at the desired temperature and flow readily, as all oil not burned, is returned to the storage tanks.

### Power House

For the manufacture of automobiles the city of Detroit possesses many advantages among which is an abundant supply of power furnished at an attractive rate, but for forging and heat treating large quantities of steam are also required. Thus while electric power could be purchased, this latter requirement could only be met by the erection of a power house of large capacity. The building was placed at one corner of the plant and covers an area 92 ft. 4 in. x 95 ft. 2 in. It houses four 750 hp. boilers fired by the underfed type of stokers. Steam pressure at the hammers is 130 lb., consequently a somewhat higher pressure must be carried in the boilers to maintain this at the hammer inlets. One stack serves the four boilers. A short distance from the power plant is the compressor station in which is installed sufficient air compressing equipment to supply air for sand blasting, operating high pressure oil burners, etc. The equipment in this station comprises four compressors of which two, with capacities of 8,000 cu. ft. and 4,000 cu. ft., operate at 40 lbs. pressure while the remaining two, whose capacities are 2,750 cu. ft. and 340 cu. ft. operate at a pressure of 100 lbs.

### Die Shop

The heart of a forge plant is the die shop since if the dies supplied are below standard the entire system will be affected. In this connection the practice for the manufacture of dies at this plant has been established on a very efficient plan. Thus in 1926 over 3,000 dies were hardened with no report of breakage.

Reference to Fig. 2 makes apparent one of the reasons for the efficiency of this department in that the equipment is most complete and adequate for the purpose.

The die shop, with the hardening and hammer repair stock rooms, has an overall length of 313 ft. 10½ in. and an overall width of 151 ft. 9½ in.; accordingly the floor space covered is 47,623 sq. ft. From this space 3,600 sq. ft. must be subtracted as one corner of the shop has not been extended.

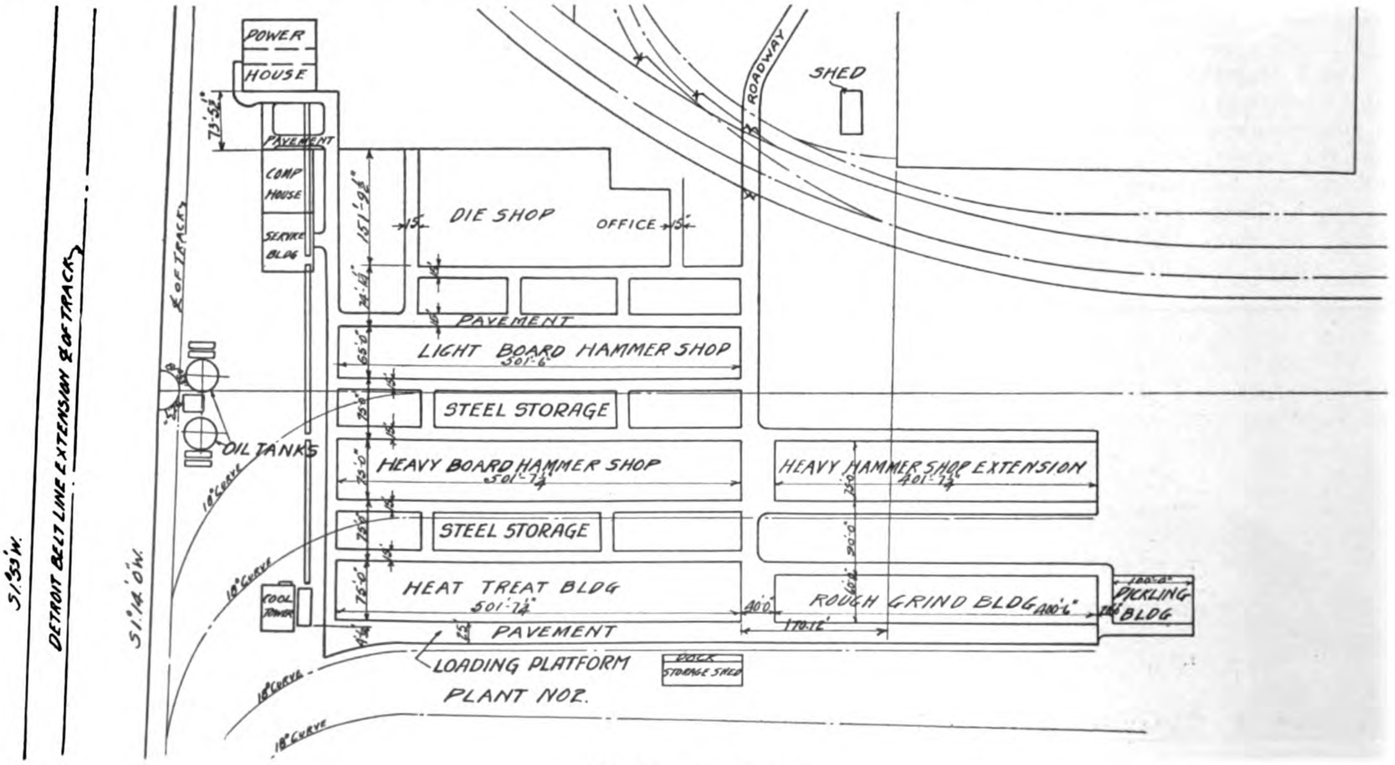

FIG. 1—Plant layout.

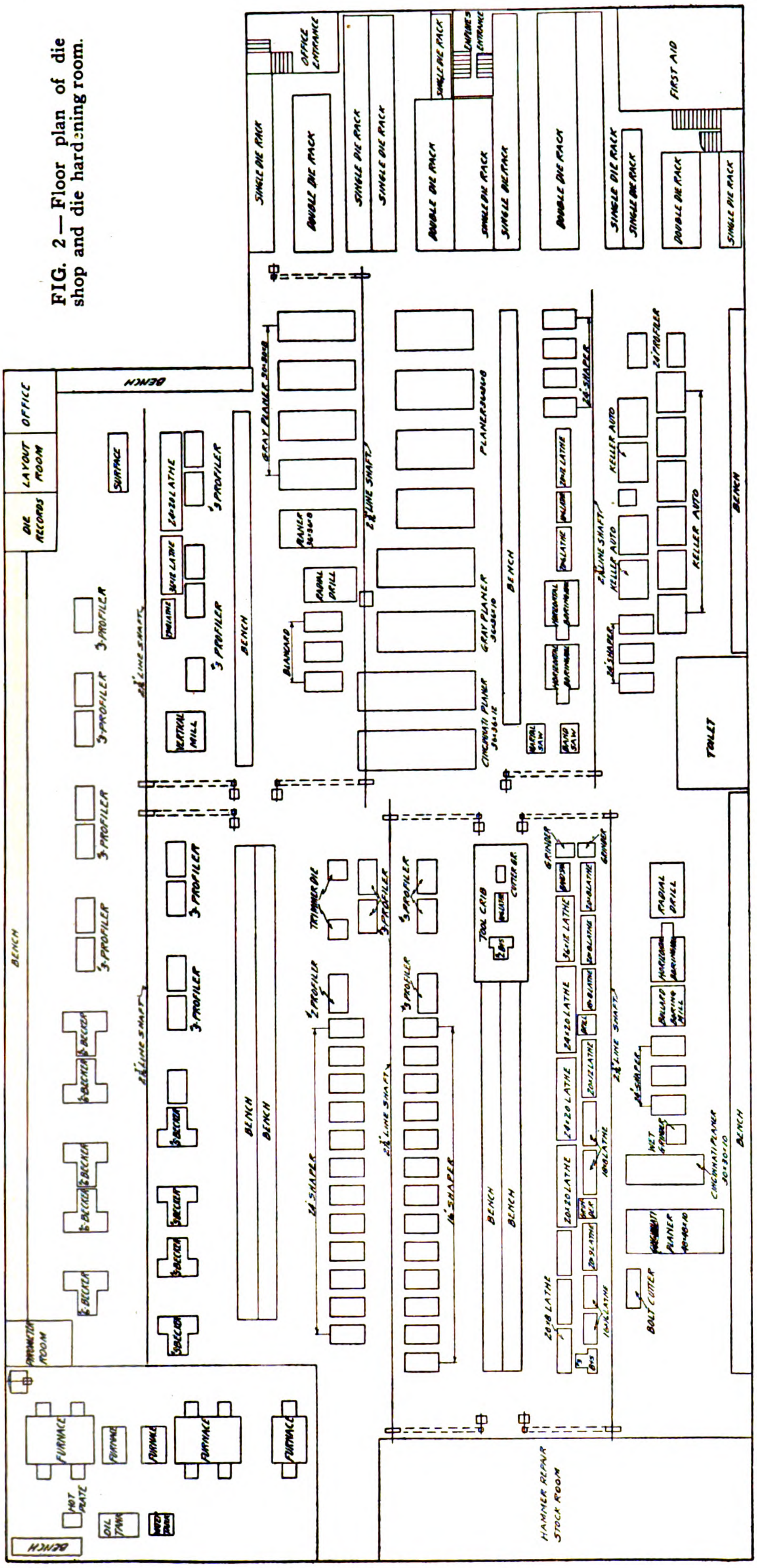

FIG. 2—Floor plan of die shop and die hardening room.

In the design of this building particular attention was directed to obtain a construction such that the lighting, both natural and artificial, would be the best for the precise work to be performed.

At night illumination is secured from Cooper-Hewitt lights well distributed throughout the room.

In Fig. 2 the location, size, make and number of the various pieces of equipment are plainly indicated. From this layout it is apparent that with equipment of such a diversified nature all operations necessary for the completion of the most complicated dies can readily be performed. Then too, these machines have been so placed as to obtain economy of time and movement in transporting dies from one operation to another and this latter feature has been further promoted by the installation of a system of overhead cranes and monorails. The overhead cranes, with a span of 9 ft., give access to every machine bordering the aisles while monorails pass over those benches and machines, not served by the cranes. Since the dies must be conveyed from the shop to the hammers, the aisles have been made wide enough to permit the passing of an electric truck.

In the manufacture of a die there are two operations of practically equal importance; the construction of the die, so that it will register the correct impression, and its heat treatment. Unless this latter treatment is correctly performed the die is not only useless, but the labor spent on it is wasted. That the significance of this fact was appreciated in this instance is manifest by the attention accorded the equipping of the heat treating department. In Fig. 2 it will be noticed that this department is located in a corner of the building. This location not only gives accessibility, but also allows the equipment to be isolated from the die room by the construction of partition walls of brick and metal.

There are five furnaces available for heating the dies; of these two have a hearth dimension of 10 ft. x 5 ft. while the remaining three are of a smaller size. For heating high speed steel two electric furnaces have been provided, together with one for preheating. The oil furnaces which are underfired, have a burner system so constructed that heat control is automatic. In these furnaces the dies are brought to the requisite temperature at a predetermined rate and when this

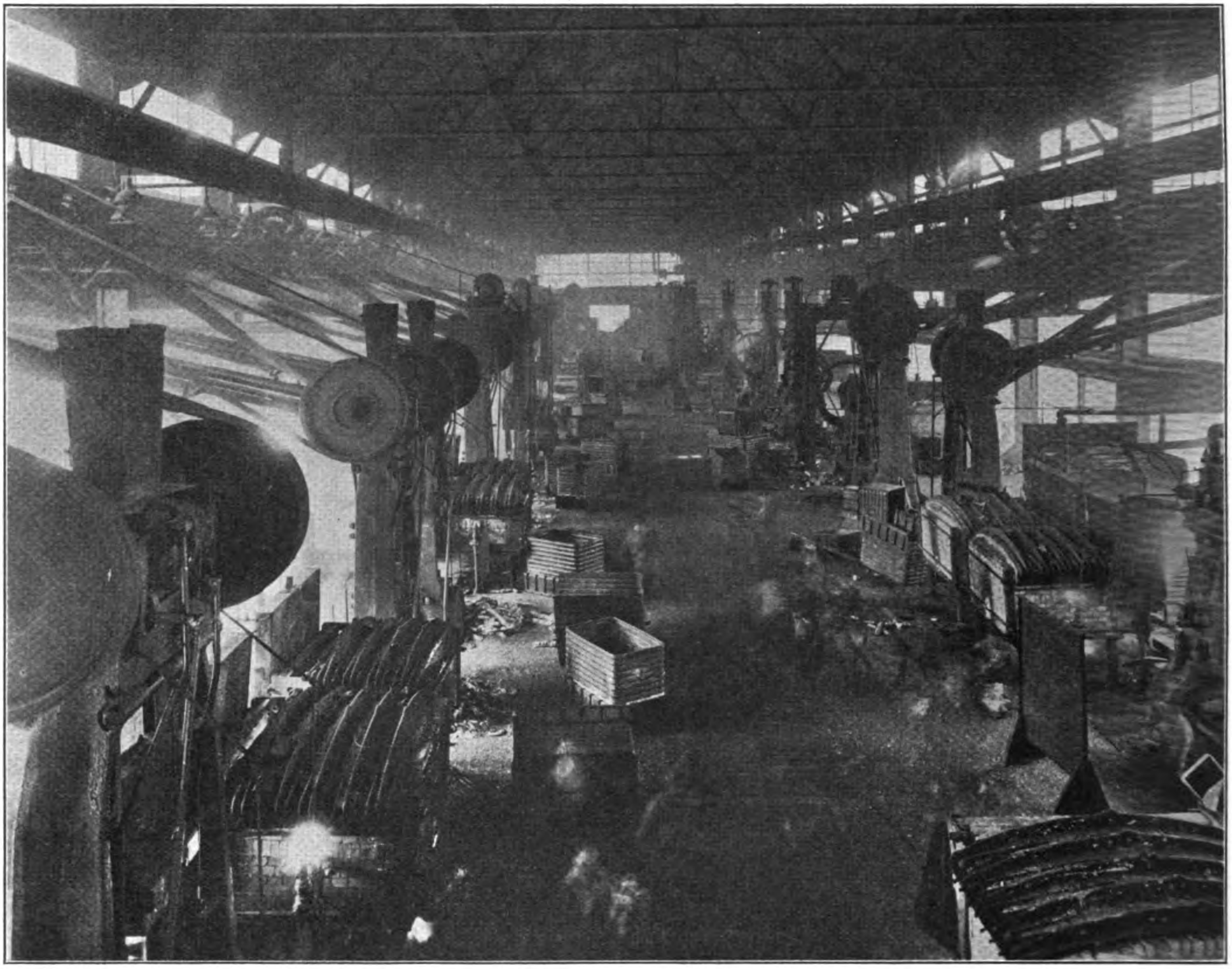

FIG. 3—Interior view of forge shop.

temperature is reached it is automatically held for a period deemed sufficient for thorough heating. The dies are then quenched in oil or water, the temperature of which is also automatically controlled. All the equipment in this department including not only the furnaces, but also all temperature regulating equipment, etc., was designed and constructed by engineers in the employ of the Dodge Brothers. Since the success of precise heating processes, such as carried out in the manufacture of dies, is so dependent upon accuracy of temperature measurements this feature has been recognized and provided for by the erection of a pyrometer room adjacent the heat treating department.

### Forging Department

One of the requisites for success in the manufacture of automobiles is a well equipped and well organized forge shop. From this shop come the cam shaft, the valve rods, the transmission gears, the crankshafts and other parts by which, and through which, the machine is motivated. These parts control the energizing of the engine and transmit its power, hence they must withstand severe usage and be durable and their quality must be superlative.

An interior view of one of the shops is shown in Fig. 3. In this view attention is especially directed to the height of the building, to the natural illumination and the large amount of open space in the sides. To the left and directly below the crane runway the electric lights can be seen. These lights are spaced about 8 ft. apart thus providing ample illumination for night work.

The three shops, for the manufacture of forgings, are located as was shown in **Fig. 1.** These shops are the light, the heavy, and the heavy hammer extension. Each shop has a roof of precast concrete slabs with two openings in every 25-ft. bay for 54-in. ventilators. The sides are formed of Kinnear doors in every bay above which is glass in steel sash. Corrugated steel is used for only a small portion of the height. The distance from floor level to the crane rail is 33 ft. thus providing adequate clearance between the hammers and cranes for any repairs or replacements necessary. In order that there might be room for a walk way along the line shafting the crane runway has been placed several feet from the face of the side columns. This feature also affords a better flow of light when the cranes are over the hammers. All flooring is of brick laid on a concrete base.

To assure the most favorable conditions, as regards atmosphere and temperature, the furnaces have been placed nearby and facing the sides of the building. By this arrangement the air is drawn through the open space below the glass and passes up to and out the 54-in. ventilators. In winter the Kinnear

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doors can be lowered so as to cut off or reduce the side openings as may be desired. Furthermore the workman always has the fresh air at his back consequently it cannot be polluted with the gases from the furnaces. Such conditions enable the men to work at maximum efficiency and in comparative comfort.

### Water-Cooled Fronts On Furnaces

Another feature which adds much to the comfort of the hammermen is the installation of a water-cooled front on each forge furnace, as can be seen in the illustration. The fronts are formed of welded steel plates with an opening at the top for the admittance of water. After flowing through the front the water passes to a sump in the floor, in which all dirt or scale is deposited. From here the water is pumped to a larger sump for recirculation to the furnaces. About 1,800 gal. pass through the fronts per minute. Replacements can readily be made by disconnecting the admittance and exit pipes.

### Burners and Furnaces

Three sizes of furnaces are in service with outside dimensions 46 in. wide x 60 in. long; 50 in. wide x 78 in. long and 54 in. wide x 98 in. long. The walls are 9 in. thick while the roofs are formed of "bungs," holding a brick on edge, consequently it is an easy matter to renew a damaged roof. Should a furnace need a general repair it is removed from its position by the overhead crane and is replaced by one which has been rebuilt. This procedure reduces delays on hammers besides allowing furnace repairs to be made more economically and to better advantage. All furnaces — except those of the continuous type — and burners were designed by engineers in the employ of the Dodge Company. Oil at a pressure of 75 lb. is mixed with air at a pressure of slightly under 2 lb. The air is supplied by eight blowers which combined have a capacity of 47,500 cu. ft. per minute. Three of these blowers are located in the heavy hammer shop, three in the light hammer shop and the remaining two in the heavy hammer shop extension.

For the heating of steel for crank shafts three Rockwell continuous furnaces were installed in the heavy hammer shop extension. These furnaces heat 3-in. rounds about 34⅜ in. long for forging under 12,000-lb. hammers.

The hammer and header equipment in each shop is as follows:

### Light Hammer Shop

5—1,200 lb. board hammers
21—1,600 lb. board hammers
1—4 in. Acme header
1—2½ in. Acme header
2—3½ in. Acme headers
2—2 in. National headers
30—trimming presses

### Heavy Hammer Shop

8—2,000 lb. board hammers
1—3,500 lb. board hammer
1—4,000 lb. board hammer
6—3,000 lb. steam hammers
5—5,000 lb. steam hammers
1—6,500 lb. board hammer
2—5 in. National headers
2—5 in. Acme headers
1—4 in. Acme header

### Heavy Hammer Shop Extension

3—12,000 lb. steam hammers
6—2,000 lb. board hammers
2—4,000 lb. board hammers
1—5 in. National header
1—3 in. National header
1—2 in. National header
2—1½ National headers

Figs. 4, 5, and 6 show the location of the hammers, furnaces, motors, and other equipment in the three shops.

The board hammers are all driven from line shafts which vary in diameter from 3 15/16 in. in the light hammer shop to 4 7/16 in. in the heavy hammer shop. These shafts are mounted in Timken roller bearings and are belt driven from a motor to a 5,000 lb. fly wheel as can be plainly seen in Fig. 3. All motors are mounted on structural steel supports at an elevation slightly higher than the hammer pulleys. This places the motors in a favorable position for a belt drive and removes them from the dust and dirt, which cannot be prevented from accumulating on the floor of a shop. On each side of the belt driven fly wheel the brackets are of cast steel, but elsewhere they are of cast iron.

In the light hammer shop a 10-ton traveling crane serves for moving all heavy loads while in the other two shops 15-ton cranes fulfill this requirement.

Thirty-three trimming presses have been installed to take care of this feature of the process.

### Movement of Material

All steel to be forged is delivered to the hammers, sheared to size, and so placed as to be easily charged into the furnaces. To facilitate economy of movement ample space has been provided between the hammers and furnaces so that electric trucks can readily move about.

After the steel has been forged and trimmed the pieces are placed in "tote" boxes (some of which are seen in the foreground in Fig. 3) and carried to the heat treating, or cleaning departments. Scrap and trimmings are likewise loaded into boxes and removed to a bin adjacent the railroad track. From this bin the scrap is placed in cars by means of a magnet carried on an overhead crane.

### Forging

Seventy-five per cent of the forgings from these shops are of alloyed steel and the major portion of this percentage is of chrome-vanadium stock.

Before the steel is received at the plant it is subjected to inspection at the works of the steel company where it must meet rigid specifications as to both physical and chemical composition. A second inspection is made after forging and before it passes to any other department.

The temperature at which forging is carried out varies according to the composition of the steel, but generally a temperature of from 2,200 deg. F. to 2,300 deg. F. is found most satisfactory. Crank shafts and front axles forge nicely at the above temperature while 1,900 deg. F. is more suitable for transmission gears, which have a carbon content of approximately 50 per cent. These gears are upset in a forging machine.

The valve rods, which are of Sil-chrome steel are subjected to three "gathering" operations and one

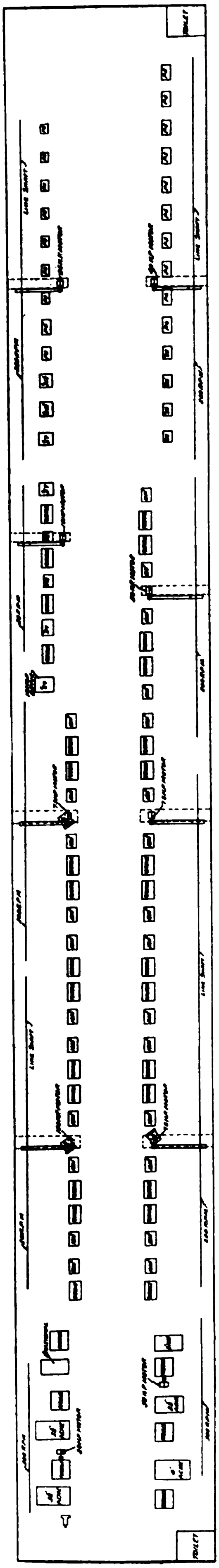


FIG. 4—Floor plan of light hammer shop.

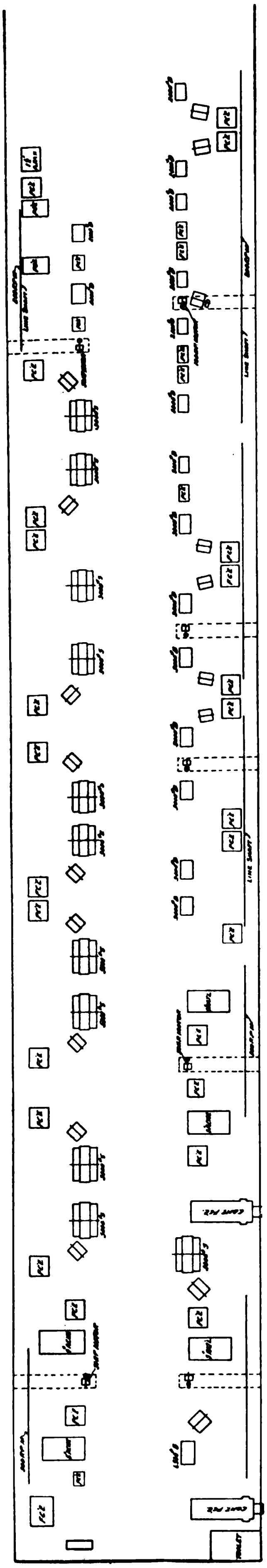


FIG. 5—Floor plan of heavy hammer shop.

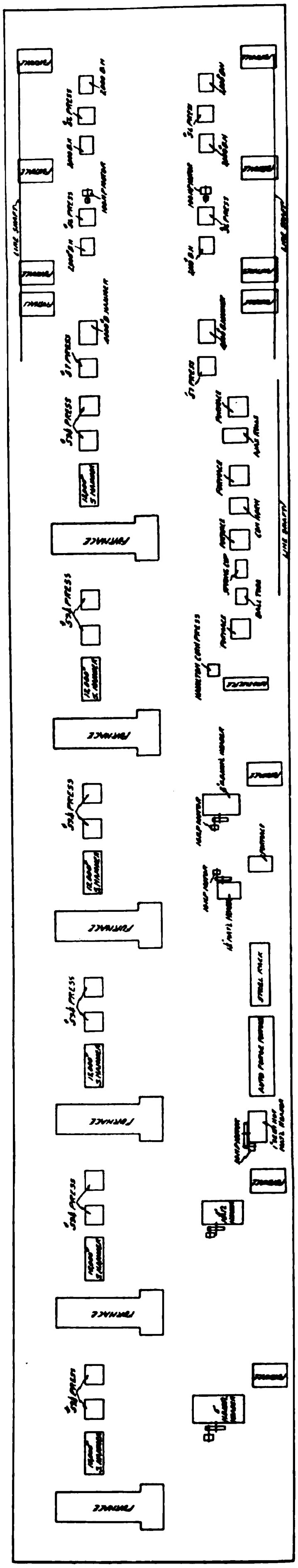
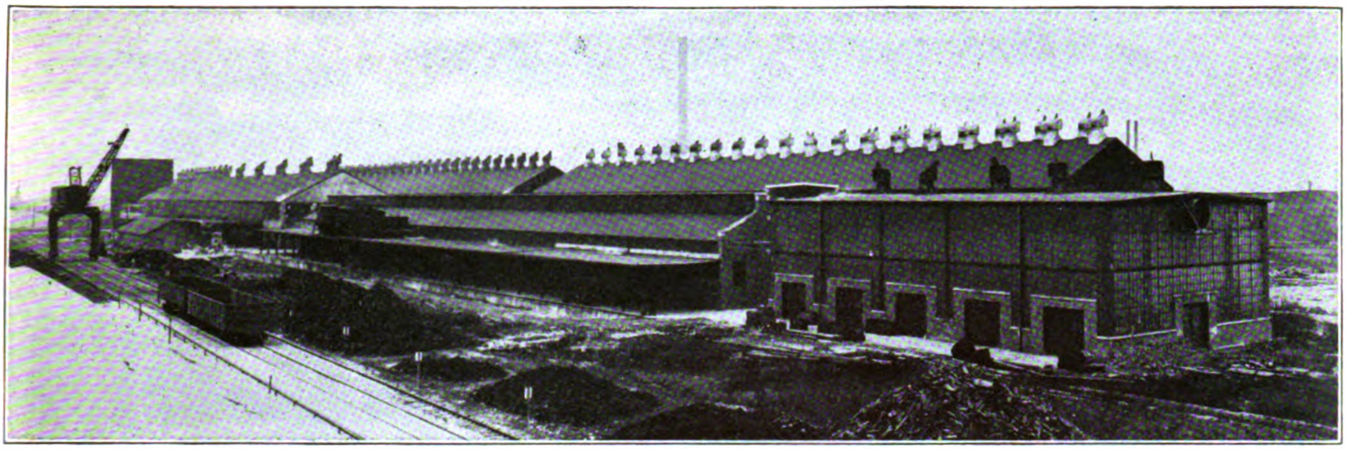


FIG. 6—Floor plan of heavy hammer shop extension.



View showing heat treating, cleaning, and pickling shops.

finishing operation. These rods will not scale under a temperature of 1,800 deg. F.

### Heat Treating and Cleaning

Heat treating and cleaning, as performed at the Dodge plant, conform to the most up-to-date practice, through equipment designed to harmonize with such practice. In the new plant the methods and processes followed have been devised by the company engineers after years of experience in the original shops on Jos. Campeau Avenue, hence the practice of today is stamped with the worthy traditions of the Dodge organization.

In Fig. 1, the relative position of all the shops, constituting plant No. 2, was indicated on a sketch, but the photograph, reproduced above, presents more clearly the location and construction of those buildings, now being considered. In the foreground, at the right, is the "pickling" shop and adjoining this, on the left, is the building in which the forgings are ground and cleaned before machining. To the extreme left the building housing the heat treating equipment can be readily distinguished by the ventilators on the ridge of the roof. A glance at the roofs of the forge shops in the rear makes apparent the thoroughness of the ventilating system in these shops.

The heat treating building has been provided with excellent ventilation and with ample glass surface on both sides and ends. This latter provision, together with the very liberal installation of electric lights, assures a well illuminated shop under all conditions. Fig. 7 furnishes further confirmation of this statement. Below the glass, on both sides, Kinnear doors afford access for the movement of materials as well as a means of increasing, or curtailing, the flow of air to the ventilators. Other constructional features are plainly visible in Figs. 7 and 8. For the movement of all heavy material, two 10-ton traveling cranes have been installed.

The routing of material to and from the several shops varies according to the parts being produced, but after leaving the forge shop each piece eventually

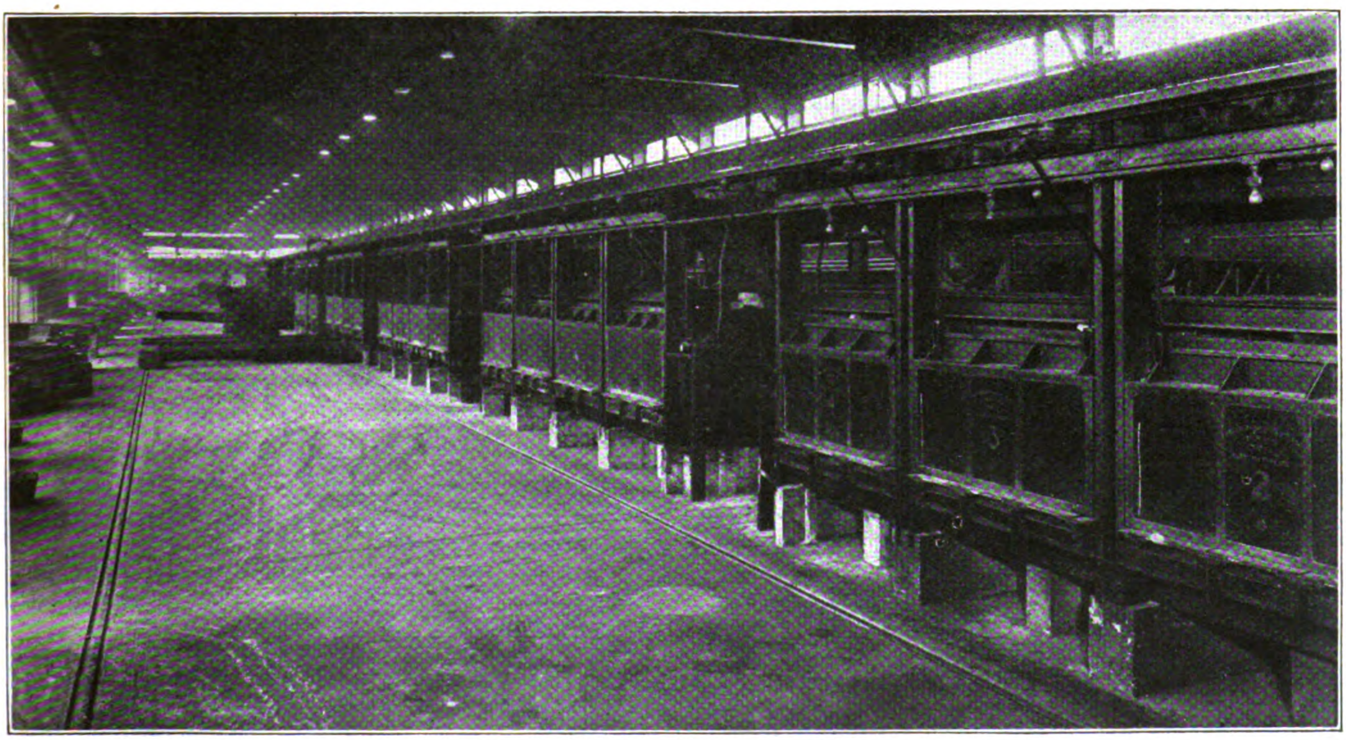


FIG. 7—Charging side of annealing and hardening furnaces.

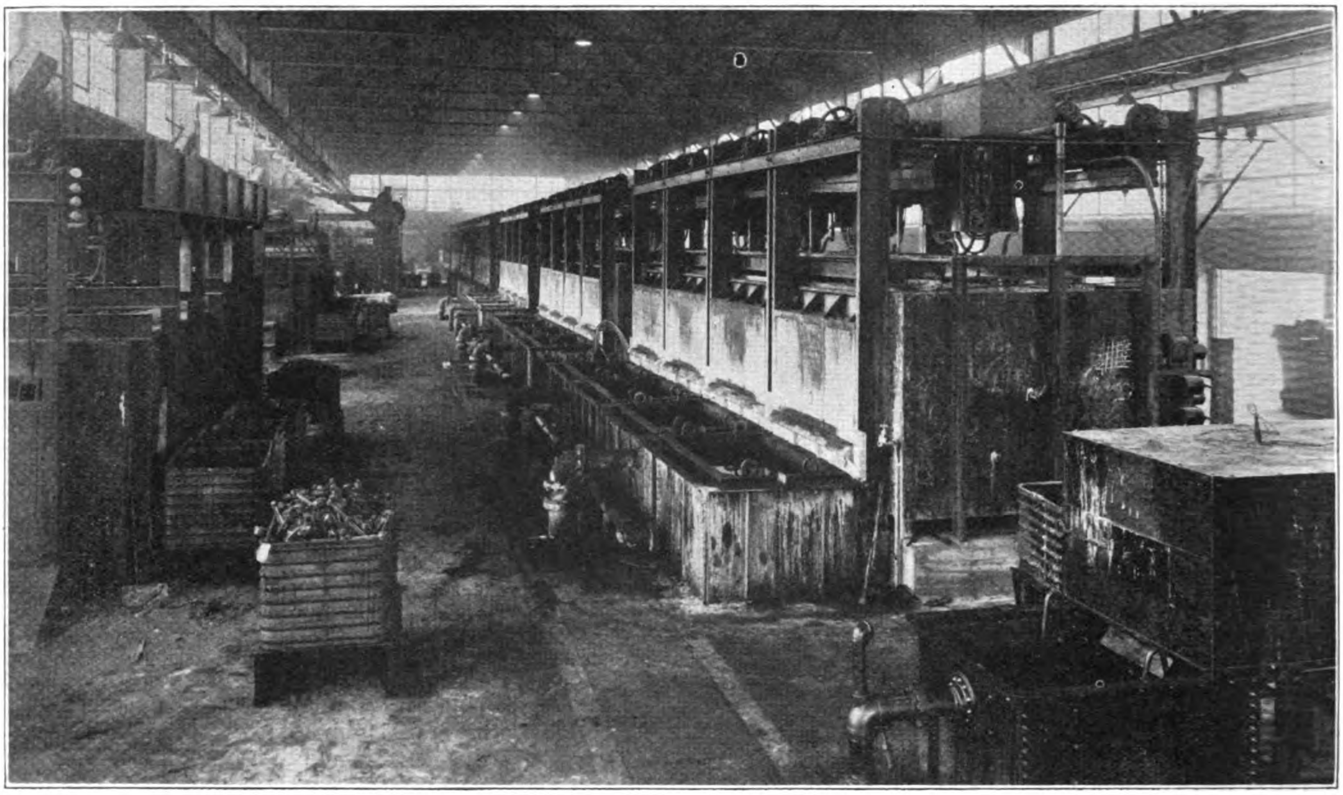


**FIG. 8—Discharge side of annealing and hardening furnaces.**

passes through the heat treating department. From this department the pieces, loaded in "tote" boxes, are carried either to the cleaning room, or are loaded in box cars, and transported to the main plant to be machined. In order to expedite this latter movement a loading platform has been built at the side of the heat treating and grinding buildings over which electric trucks convey the semi-finished forgings directly into the cars.

All furnaces in the heat treating department are electrically heated; furthermore they are electrically controlled both as to maintenance of temperature and movement of parts. Thus, the row of furnaces shown in Figs. 7 and 8 are heated by elements suspended directly under the roof and spread beneath the hearth; temperature is held at the desired degree by thermostatic control; likewise all doors are raised or lowered by electrical operated mechanism.

There are eight of these furnaces in the row, each with four chambers separated by division walls. The hearths, which have an effective area of 40 sq. ft. each, are formed of alloyed heat resisting metal, ½ in. thick. The doors, which have been placed at both ends of the individual chambers, in order that material may be simultaneously charged at one end and discharged at the other, are constructed of steel plate lined with fire brick, behind which, a row of insulating brick has been placed.

The charging and discharging of the furnaces are performed, solely, by mechanical means. This is done by an electrically operated machine which travels on rails along the furnaces, as shown in Fig. 7. When a furnace is to be discharged the machine picks up a shallow box, containing the pieces to be heat treated, and pushes this box into the furnace. As the box passes over the hearth it pushes before it the material, which has been heated consequently this material falls out the opposite side into baskets. After the box has been placed in the furnace a contrivance which is an essential part of the charging machine, withdraws the plate forming the bottom of the box whereupon the pieces drop to the hearth. Thus the loading and unloading of the furnaces is executed in one movement. The charging machine, which is of 1½ tons capacity, is capable of simultaneous charging and discharging a load of 1,250 lb., the average load per box, in 20 seconds.

From the floor plan of the heat treating department, Fig. 9, it will be seen that of the eight machine-charged furnaces, five are used for hardening and three for annealing. Fig. 8 shows the discharge side of these furnaces.

Baskets, of some form, receive the heated pieces as they fall from the furnaces. If the material is to be hardened these baskets are immersed in steel tanks from which they are removed by the overhead crane, but if the steel is only to be annealed, it is caught in a skid box and transported direct to the cleaning room. The perforated baskets in the solution tanks are made of steel and are so constructed that the bottom can be dropped and the contents deposited into skid boxes. These skid boxes are then carried to the "drawing" furnaces.

### Cooling Solution

Those conversant with hardening practice are well aware of the necessity for maintaining the cooling solution at a constant temperature; accordingly, this feature has received attention commensurate with its importance. The solution employed contains approximately 8 per cent of caustic soda and is required in such a quantity that 1,800 gal. per minute, must be pumped through the tanks into which the pieces fall. Consequently in order to reduce the temperature of this large amount of liquid so that it will not exceed 110 deg. F. or 115 deg. F., a cooling system was im-

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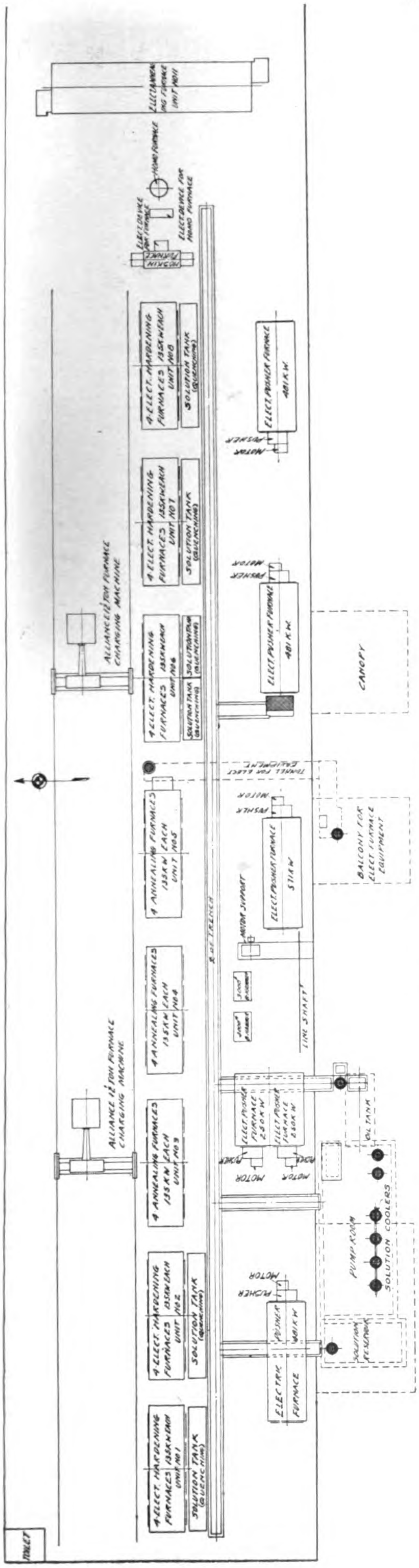
TOILET
HOMO FURNACE
ROTARY FURNACE
4 ELECT. HARDENING FURNACES 135 K.W. EACH
SOLUTION TANK (QUENCHING)
ELECT. PUSHER FURNACE
MOTOR
PUSHER
ALLIANCE 1/2 TON FURNACE CHARGING MACHINE
CANOPY
TUNNEL FOR ELECT. EQUIPMENT
BALCONY FOR ELECT. FURNACE EQUIPMENT
4 ANNEALING FURNACES 135 K.W. EACH
MOTOR SUPPORT
LINE SHAFT
OIL TANK
PUMP ROOM
SOLUTION COOLERS
SOLUTION RESERVOIR
ELECTRIC FURNACE

FIG. 9—Floor plan of heat treating building.

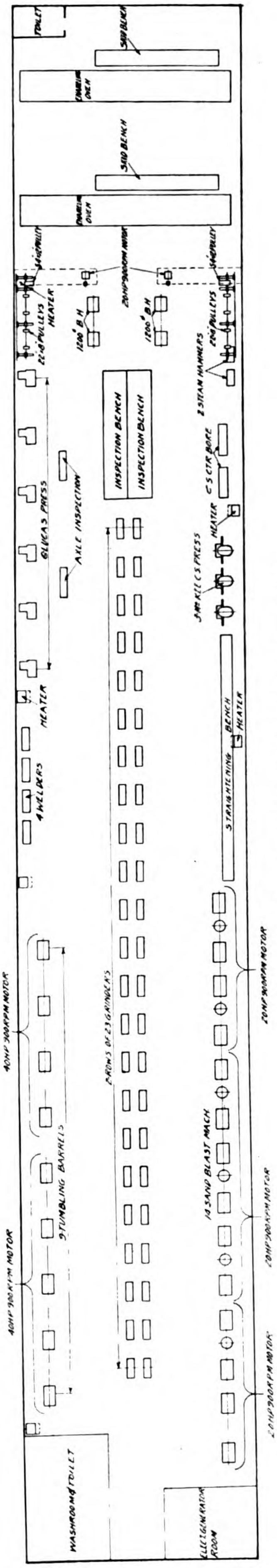

FIG. 10—Floor plan of grinding and cleaning shop.

perative. Such a system has been installed in a rather elaborate manner as is evidenced by reference to Fig. 9.

The pump room is located below ground level and at one end of the building, while nearby is a reservoir with a capacity of 15,000 gal. From this reservoir the solution is pumped through pipes, laid in trenches, to the several tanks at the furnaces. In these tanks the liquid is heated by the pieces which fall from the furnaces, at a temperature of approximately 1,650 deg. F. The solution is now returned to a series of coolers, located in the same room as the pumps, where the heat is extracted by means of a current of water which flows through the coolers. In this manner the temperature of the solution is lowered, but at the same time the temperature of the water is raised. This latter action requires the provision of some means for cooling the water inasmuch as it is advisable for the sake of economy to use the same water continuously. To effect this cooling the water is pumped to a tower where it falls over grids to a basin and in falling, the temperature is reduced. The trenches in which the pipes for the circulation of the solution are laid, are of concrete construction with cast iron plates for the covering. Should it be desired oil can be used as the cooling medium instead of the NAOH solution.

Besides the eight furnaces previously described, there are four single chamber pusher type, with hearths 25 ft. long and 5 ft. wide; one twin chamber pusher type, with hearths 15 ft. long by 5 ft. wide, and one small furnace for heating connecting rod bolts.

The pusher type furnaces have alloyed heat resisting rails imbedded in the hearth on which the trays containing the material rests, while between these rails the space is covered with metal of a composition similar to that of the rails. These furnaces heat the pieces for "drawing" after they have been hardened.

Connecting rod bolts are heated to 1,550 deg. F. in a small Hoskins continuous furnace at the rate of 900 per

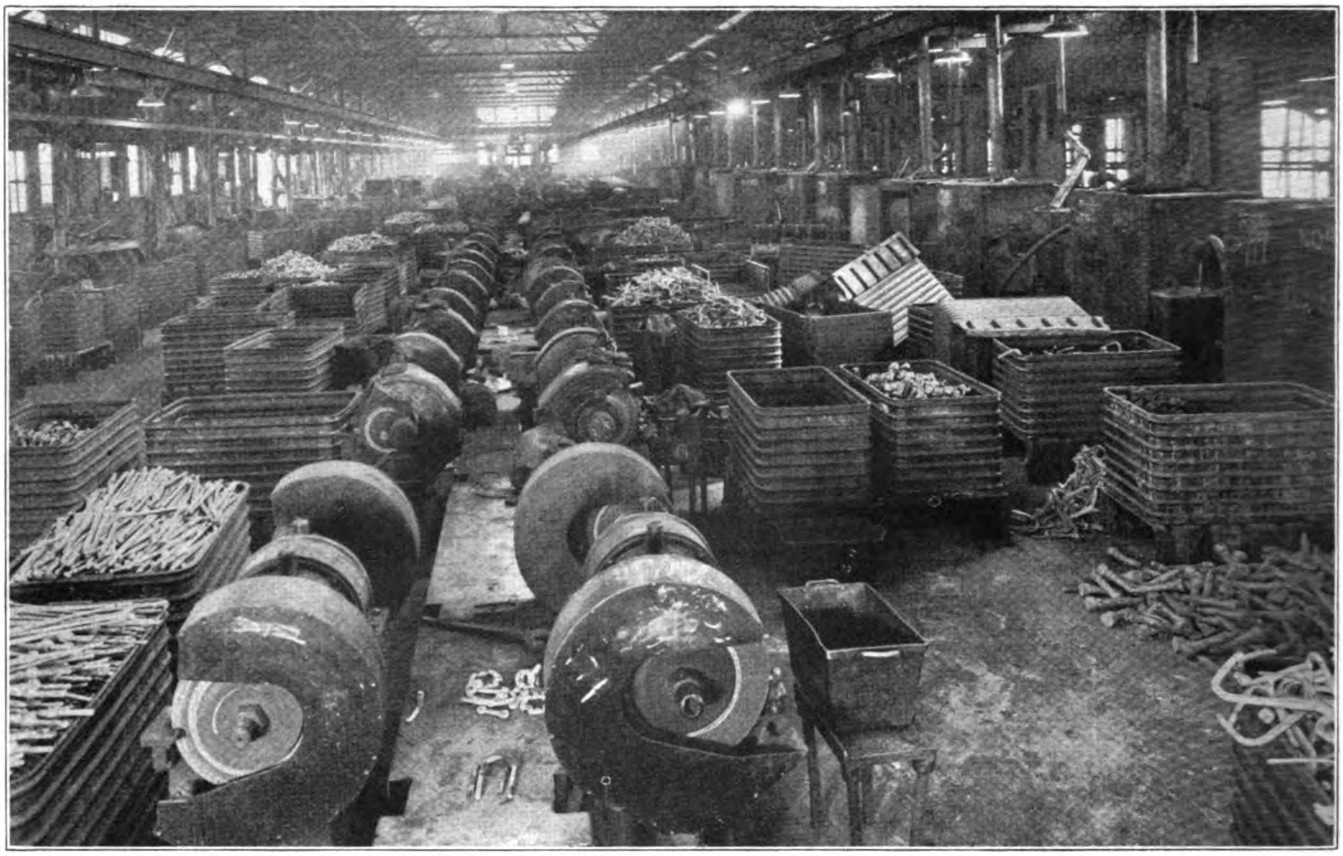

FIG. 11—View in grinding and cleaning shop.

hour and are then individually queched in oil. For every bolt which passes into the tank one gallon of oil is delivered. A basket receives the bolts as they fall from the furnace. This equipment as a whole, has operated to such an efficiency that the rejections for the year have been less than one-tenth of 1 per cent.

Another furnace of somewhat different construction has been installed for annealing or normalizing transmission gears. This furnace has a length of 47 ft. and is so constructed that the gear is gradually heated to a temperature of 1,525 deg. F., where it is held until thoroughly soaked, after which the temperature is reduced to approximately 1,320 deg. F., when it is discharged. The pieces are moved through the furnace by a pusher mechanism.

There are many distinguishing features in this department which call for extended description, but which can here only be briefly mentioned.

One of these features is the complete and elaborate system of temperature measurement and control. The pyrometer room, from which this control is exercised, is located on a balcony to the side of the center of the building and is connected to the floor of the building by a tunnel through which pass all the wires from the thermo-couples to the recording instruments. The 55 pyrometers serving to indicate the temperatures carried in the furnaces are so arranged that a permanent record of every heat or "batch," is recorded on a chart. Not only are temperatures recorded, but the time of heating as well. There is thus available at all times, a complete record of the treatment of every piece of metal which has passed through the furnaces.

In order that any forgings may be straightened or made true to form after they have passed through the heating processes, two 3,000-lb. restrike hammers have been erected near the center of the shop. These are of much benefit in reforming pieces of thin section or those that easily warped.

While much importance is attached to the operations so far covered, one other phase of plant practice is of utmost concern to insure the success of all heat treating—careful and correct inspection. It is not only necessary that all inspecting be performed conscientiously but the methods must be approved by time and usage. In this connection inspection at the Dodge plant is both thorough and according to the best practice. All pieces are tested by either Rockwell, Brinell, or Scleroscope instruments, consequently their hardness must fall within limits found to assure the longest service. Thus crankshafts are tested for Brinell hardness, connecting rod bolts are inspected at three places for Rockwell hardness, and other pieces must pass inspection for Scleroscope hardness. As proof of the efficiency of the operations at this plant attention is directed to the fact that rejections for 1926 were less than 1 per cent.

### Cleaning Department

A study of Fig. 10 bears conviction that the proper cleaning of each piece is assured in the plant under discussion. The equipment is not only adequate but diversified enough to cover every contingency. Thus there are:

| | |
|---|---|
| 92 | grinding wheels |
| 9 | tumbling barrels |
| 14 | sand blast machines |
| 4 | welding machines (for butt welding) |
| 6 | Lucas presses |
| 3 | McKee presses |
| 4 | 1,200-lb. board hammers |
| 2 | steam hammers. |

An idea of the construction of the building and its contents can be gained from Fig. 11. In the foreground are the grinding wheels from which the dust is drawn through pipes. These pipes have been placed between opposite grinders as can readily be seen. After passing from the connecting pipes the dust is deposited in collectors from which it is removed and loaded into cars for shipment to blast furnaces, where it is converted into iron. As this dust contains about 78 per cent of iron it is of value for this purpose.

### Pickling Department

The building housing the two pickling machines is 100 ft. long and 60 ft. wide. In the design of this building particular attention was directed to its ventilation and illumination. The former was assured by installing large capacity fans at both ends of the building while by making the enclosure entirely of glass the maximum lighting effect was secured.

Only two pickling machines are in service, but provision has been made for a third which will be available whenever conditions warrant the additional capacity. The machines now in use are of the four-armed Mesta type, with a capacity of three tons per hour. Each arm supports a basket holding 8,400 lb. of metal. Three wooden tanks, see Fig. 12, contain the pickling solution into which the forgings are dipped. In the first tank the solution is 90 per cent water and 10 per cent sulphuric acid; in the second 97 per cent water and 3 per cent acid, while in the third tank water alone is used. By hourly titration, it is possible to detect any variations in the strength of this solution and bring it back to the strength desired. As it is necessary to heat the pickling liquid an automatic control system has been provided by means of which the flow of steam is accurately controlled.

Directly outside the building has been placed an acid storage tank into which the acid is unloaded from tank cars. This unloading is accomplished by admitting air at 40 lb. pressure to the car in consequence of which the acid is forced to flow in the storage reservoir. In this manner a car of acid can be emptied in two hours time.

### Welfare and Safety First

It has been the aim in this article, to present an adequate description of one of the most modern plants devoted to forging and heat treating, but such a description is incomplete if only the phyical aspects are considered. A plant such as this, employing thousands of men engaged in an accupation of a somewhat hazardous nature, must look after their welfare, besides affording every protection against injury. Both these features of plant administration have been provided for in a liberal manner.

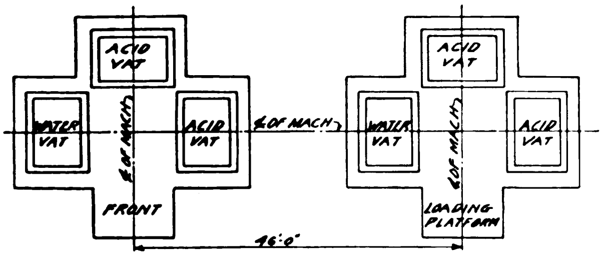

FIG. 12—Plan of pickling machines.

Before engaging in work here each employe is given a thorough physical examination to insure his fitness for the work he is to perform. Such an examination furthermore is a precaution against the error of placing a man in a position for which he is not physically suited and where, due to some weakness, he may be liable to injury. Hence the examination protects the employe as well as the Dodge Company. Should injury occur "first aid" is available in a room furnished with two beds and other facilities for such contingencies.

Each shop is equipped with sufficient showers, lockers, and wash rooms to accommodate all employes when the plant is working at capacity. Moreover a restaurant has been opened in the plant so that it is unnecessary for men to carry food.

## U. G. I. to Control Day & Zimmermann, Inc.

Subject to the approval of its stock holders and meeting to be called this fall, The United Gas Improvement Company will acquire the controlling interest in Day & Zimmermann, Inc., Philadelphia, through an exchange of securities.

President A. W. Thompson, in making this announcement, said that he desired to emphasize the fact that Day & Zimmermann, Inc., will continue to be very active in the management and operation of the various properties which have been so successful under their direction. This transaction, involving properties in 14 states, has been under way for several months. When all the details of financing are worked out the stockholders and customers of the various Day & Zimmermann properties will find that their business will continue to be operated on the same high standard under the leadership of Charles Day and John E. Zimmermann, aided by the same men whose skill and vision have placed the management in the forefront of the public utility industry.

The officers of Day & Zimmermann, Inc., are: Charles Day, chairman of the board; John E. Zimmermann, president; Conrad N. Lauer, vice president; Nicholas G. Roosevelt, vice president; Daniel M. Bates, vice president.

## The Use of Metallurgical Limestone

(Continued from page 384)

depth of 1 or 2 ft. over a basic lining of fire brick. The essential requirements of a good lining are (1) refractoriness, (2) resistance to corrosion of slag or metal, (3) absence of disintegration on cooling, (4) absence of cracking on heating, (5) mechanical strength to resist molten flux, (6) low cost. For (1) and (2) there must be low percentages of silica and alumina. For (3) the magnesia content must be high. Dolomite is used in preference to magnesite on account of its much lower cost. The approximate composition of a satisfactory furnace lining is $SiO_2$ less than 1 per cent $Al_2O_3$ and $Fe_2O_3$ together less than 1.5 per cent $MgCO_3$ at least 35 per cent, the remainder consisting of $CaCO_3$. Dolomite is used for patching the slag lines where scorification of the hearth is heaviest. It may be used in the uncalcined form.

The writer desires to acknowledge many helpful suggestions from S. A. Kinney, T. L. Joseph, and C. H. Herty, Jr., metallurgists of the Bureau of Mines.

# *The Annealing of Mild Steel Sheets*[*]

## Investigation Discloses the Influence of Temperature On the Properties, as Determined by the Erichsen Test, of Sheets of Varying Thickness

By PROF. C. A. EDWARDS and J. C. JONES[†]

IT is well known both by manufacturers and users of mild steel sheets, such as are so extensively used in the tinplate, blackplate, and galvanized sheet trades, that these materials sometimes possess abnormal properties which render them unsuitable for certain purposes. While a considerable amount of experimental work has been done with the object of throwing more light on these irregularities, and a great deal is known concerning them, there is still a real need for further systematic research concerning each of the variable factors that might be encountered in the course of the different stages of their manufacture. Perhaps the three most important items which ought to be considered in this connection are:

(a) The chemical composition of the steel,

(b) the condition of the steel in the melting furnace immediately prior to tapping, and the character of the ingots obtained, and

(c) the annealing of the rolled sheets.

It is proposed to make extensive investigations of these and other variables that are known to affect the final properties of the sheets, and the present paper represents the first step in that direction. In this paper, however, the authors' attention will be confined to the influence of annealing temperature. This question of annealing is being examined first, not because it is suggested that it is more important than any other, but rather because it can be more easily brought under scientific control for investigatory purposes. Further, the information so obtained should prove extremely useful in constituting a preliminary survey, by indicating the directions along which other work should be planned.

At this stage a few general remarks regarding the composition of the steel used for the purpose under consideration will not be out of place.

The carbon content is usually about 0.10 to 0.12 per cent, though it may occasionally be found to be as high as 0.17 per cent. The percentage of manganese varies between, say, 0.32 and 0.45 per cent, but most sheets will be found to contain approximately 0.4 per cent. The silicon content is, as a rule, not more than a trace, say, 0.01 to 0.02 per cent, but occasionally some "black sheets" are found to contain as much as 0.15 per cent. The phosphorus and sulphur vary within very wide limits, according to the purposes for which the sheets are to be used; in the case of sheets to be subjected to much cold-work, e.g., deep stamping, severe bending, or seaming, the phosphorus and sulphur contents are both often well below, say, 0.05 per cent, but in other instances the amount of each element may be found to be considerably higher.

The ingot is rolled into a bar of which the width and thickness vary according to the gauge and size of the sheets it is ultimately intended to produce. The bar is cut up into pieces of approximately the same length as the width of the sheets to be made. During this rolling in the sheet or tinplate mills, the plastic deformation which occurs causes elongation almost entirely in the direction at right angles to the axes of the rolls, with little or no change in the other direction. The reheated bar is fed into the rolls with its long side parallel to the central axes of the rolls, and in order to facilitate this operation the original bars are made with bevelled edges.

It will thus be seen that in the rolling of bars into sheets elongation occurs in a direction at right angles to that in which deformation had occurred in the rolling of the ingot into bar form. Broadly speaking, it may be stated that in the first sheet-rolling operation the rolling is continued until the bar has become about twice the length of the required sheets. It is then doubled, reheated, and again rolled; the rolling, doubling, and reheating, etc., being repeated a number of times according to the thickness of the sheets being made. The doubled sheets are prevented from welding, or sticking together during subsequent rolling, by the film of oxide of iron which is folded in between the sheets of metal. When rolling is completed, the bundle or pack of sheets is sheared to size, the "rough" and "folded" edges being thus cut away. The sheets are then "opened" or separated from one another, and at this stage they are described as being in the sheared and opened condition, or simply "S and O." The sheets used throughout the present investigation had reached this stage of manufacture.

Although the rolling operations thus briefly referred to are carried out while the steel is hot, the temperature, especially toward the finishing stages, is invariably below that at which spontaneous annealing of mild steel takes place. The sheets are, therefore, never in their softest condition at this stage and contain residual rolling stresses, and possess a deformed microstructure.

### Manufacture of Tinplate

In the manufacture of tinplates the next operation is a pickling in sulphuric acid for the purpose of removing the oxide of iron, or scale, from the surfaces of the sheets, followed by what is known in the trade as black-annealing. In some instances, such as, for example, the galvanized sheet trades, this annealing is carried out before the pickling. Black-annealing is a moderately high-temperature annealing, and the temperature may vary between 750 deg. C. and 920 deg. C. In this operation, what may be described as the rolling stresses are removed, and the internal microstructure of the metal is more or less refined according to the temperature reached. If this temperature is 920 deg. C. or over, complete recrystallization or refining of the steel takes place, but at lower temperatures these changes are incomplete.

The quality of the sheets, so far as this is defined by their capacity to withstand deep-stamping and bending operations, is in no small degree determined by the temperature to which they are raised during black-annealing. Theoretically, this temperature should be above the highest critical point, say 920 deg. C., if the maximum softness is required. Under existing commercial conditions, however, with the so-called pot-annealing, it is impossible to so control the operation as to guarantee that each sheet in the pot has been heated to 920 deg. C.; indeed, it is not going too far to say that with a large proportion of the sheets it would be undesirable to reach such a high temperature. This is particularly the case when dealing with light gauged sheets, because of the increased wastage that would occur as a result of the sheets welding or sticking together.

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[*] Abstracted from paper delivered before the British Iron and Steel Institute, May 6, 1927.

[†] University College, Swansea.

It was with a view to determining the varying effects upon the properties of the sheets of this rather wide range of temperature that the present investigation was undertaken. It was also thought that the data so obtained would prove very useful as a basis of reference for further investigations.

The experiments that have been carried out may be classified as follows:

The determination of the influence of varying annealing temperatures upon the values obtained in the Erichsen test with sheets 0.33, 0.5, and 1.25 mm. thick.

## Influence of Annealing Temperature on the Erichsen Values

*Experiments with sheets* 0.33 *mm. thick*—The composition of the steel sheets used in this series of experiments was: carbon 0.14, sulphur 0.095, phosphorus 0.045, and manganese 0.41 per cent.

The sheets had been rolled in packs of eight, and in the sheared state measured 19 in. x 14 in. From an examination of the scale patterns on the sheets it was possible to arrange them in their original positions in the pack. After doing this, the whole pack was carefully cut up into pieces 3½ in. x 2½ in., and identification marks were made on each piece. Pieces cut from corresponding positions of each sheet were used for each annealing temperature, thus making eight sheets for each temperature. The annealing experiments were carried out in an electric muffle furnace whose internal dimensions were 10 in. x 4 in. x 2½ in. The temperatures were measured by means of a platinum, platinum-rhodium thermocouple inserted through a small hole in the back of the furnace and protected by a sheath of fused silica. A millivolt meter of a portable type was used for reading the temperatures; the thermocouple was repeatedly checked, and was found to remain constant. Each batch of test specimens was wrapped in a double thickness of very thin mild steel sheet as a precaution against oxidation.

Annealing experiments were made at intervals of 50 deg. C. between 400 and 1,000 deg. C. When a marked change in the Erichsen value between any two series of tests was observed, a further batch of sheets was annealed at a temperature midway between those at which the two series had been annealed, with the object of more accurately determining the temperature at which the change in the properties occurred. The range of temperature between 400 deg. C. and 1,000 deg. C. was selected because this embraces all the temperatures at which mild steel sheets are annealed commercially.

The duration of annealing was in all cases one hour, the operation being carried out as follows: the furnace having been heated to the required temperature, the pack was put in, and the temperature maintained for an hour. While the pack was in the furnace, the temperature indicator was kept under strict observation to insure that the temperature fluctuations were not greater than ± 5 deg. C. At the end of the annealing period the packs were withdrawn from the furnace, placed on an asbestos pad and allowed to cool in air. Each piece was tested in the Erichsen machine, vaseline being smeared on that side of the test-piece upon which the ball pressed.

For the purpose of illustrating the differences in the values obtained from the eight samples annealed at the same time, three series of results are given below. It will be seen that, considering the nature of the material, the results are very satisfactory and the agreement improves as the temperature is raised.

### ERICHSEN VALUES

**Eight sheets annealed together for one hour at 450 deg. C.:**

| S | T | U | V | W | X | Y | Z | Total | Average |
|---|---|---|---|---|---|---|---|---|---|
| 4.0 | 4.0 | 4.15 | 4.4 | 4.45 | 4.1 | 4.5 | 4.75 | 34.35 | 4.3 |

**Eight sheets annealed together for one hour at 700 deg. C.:**

| S | T | U | V | W | X | Y | Z | Total | Average |
|---|---|---|---|---|---|---|---|---|---|
| 6.5 | 6.8 | 6.5 | 6.4 | 6.55 | 6.8 | 7.1 | 6.85 | 53.5 | 6.7 |

**Eight Sheets annealed together for one hour at 900 deg. C.:**

| S | T | U | V | W | X | Y | Z | Total | Average |
|---|---|---|---|---|---|---|---|---|---|
| 7.9 | 8.3 | 8.1 | 7.8 | 8.0 | 8.1 | 8.1 | 8.1 | 64.4 | 8.05 |

The values obtained by taking the average of eight tests for each temperature are given in Table I:

**TABLE I**

**0.33 mm. Sheets. Relation between Erichsen Values and Annealing Temperatures.**

| Annealing Temperature deg. C. | Mean Erichsen Value | Annealing Temperature deg. C. | Mean Erichsen Value |
|---|---|---|---|
| 400 | 4.52 | 750 | 6.9 |
| 450 | 4.3 | 800 | 8.0 |
| 500 | 4.58 | 850 | 7.0 |
| 550 | 4.67 | 875 | 7.1 |
| 600 | 4.48 | 900 | 8.0 |
| 625 | 4.7 | 950 | 8.3 |
| 650 | 6.4 | 1000 | 8.3 |
| 700 | 6.7 | | |

*Experiments with sheets* 0.5 *mm. thick*—One sheet 72 in. x 36 in. was used for these tests, the composition of the steel being as follows: carbon 0.10, sulphur 0.081, phosphorus 0.042, and manganese 0.39 per cent.

Six results were obtained for each annealing temperature. The averages of these are given in Table II:

**TABLE II**

**0.5 mm. Sheets. Relation between Erichsen Values and Annealing Temperatures.**

| Annealing Temperature deg. C. | Mean Erichsen Value | Annealing Temperature deg. C. | Mean Erichsen Value |
|---|---|---|---|
| 400 | 5.3 | 750 | 8.04 |
| 450 | 5.04 | 800 | 8.07 |
| 500 | 5.07 | 850 | 8.1 |
| 550 | 5.3 | 875 | 8.2 |
| 600 | 5.85 | 900 | 8.8 |
| 625 | 6.7 | 950 | 8.9 |
| 650 | 8.2 | 1000 | 8.83 |
| 700 | 8.2 | | |

*Experiments with sheets 1.25 mm. thick*—The composition of the material used was as follows: carbon 0.08, sulphur 0.031, phosphorus 0.014, manganese 0.30 per cent, and silicon a trace.

The amount of this material available was insufficient to permit of a large number of tests for each temperature over the whole range that was examined in the case of the previous material. In consequence, it was decided to confine the experiments to the range of temperature between 550 and 1,000 deg. C.

Eight tests were made for each temperature, and the averages of these are given in Table III:

TABLE III

**1.25 mm. Sheets. Relation between Erichsen Values and Annealing Temperatures.**

| Annealing Temperature deg. C. | Mean Erichsen Value | Annealing Temperature deg. C. | Mean Erichsen Value |
|---|---|---|---|
| 550 | 9.1 | 800 | 10.9 |
| 600 | 9.86 | 850 | 10.95 |
| 650 | 10.9 | 900 | 11.25 |
| 700 | 10.8 | 950 | 11.2 |
| 750 | 10.95 | 1000 | 11.3 |

## Discussion of the Results

On referring to the results obtained with the first series of sheets having a thickness of 0.33 mm. it will be observed that practically no change in the Erichsen values is brought about by annealing at any temperature below 625 deg. C. This means that, with these sheets, the rolling stresses left in the material after hot-rolling are not removed to any appreciable degree below that temperature. Between 625 deg. C. and 650 deg. C., however, there is a marked improvement in the Erichsen values, which no doubt corresponds with the temperature at which cold-work is almost completely removed from steel of this composition. Between 650 deg. C. and a little below 900 deg. C. there is a further though small improvement, the greater part of which occurs between 650 deg. C. and 750 deg. C. At 900 deg. C. another improvement takes place which, of course, is due to the recrystallization of the steel on passing through the $A_3$ change.

The data obtained with sheets 0.5 mm. thick are given in Table II. It will be noticed that the general feature are very similar to those in Table I, the only noteworthy difference being that, in this instance, there is a tendency for the Erichsen values to decrease somewhat on raising the annealing temperature above 700 deg. C. and up to 870 deg. C., as compared with those obtained by annealing at 650 deg. C. This feature is rather significant, for there is no doubt that the decrease shown between 700 deg. C. and 875 deg. C. is due to the growth of ferrite crystals. The facility with which this type of crystal growth takes place undoubtedly varies in different kinds of sheets, and is possibly associated with, or dependent upon, the manner in which the pearlite is distributed in the ferrite of the steel, and also upon the amount of work put upon the steel in the last few passes through the hot-rolling mill and the temperature of the mill during this period—in other words, the degree of deformation which has occurred below the spontaneous annealing temperature.

It is interesting to note that, on this view, it might prove possible, by annealing for short periods of time at 600 deg. C. to 700 deg. C. (thus getting the ferrite in the form of small crystals), to obtain results almost as good as can be obtained by annealing above $A_3$; provided, of course, that the degree of deformation below the spontaneous annealing temperature were sufficient to cause complete recrystallization of the ferrite on heating to 700 deg. C. Evidence having a bearing upon this aspect of the question has been published by one of the present authors and Mr. Pfeil, and the effects of varying degrees of cold-work upon crystal growth of ferrite were discussed.

With regard to the influence of the $A_3$ change, it will be noticed from Table II that the improvement in the Erichsen values, caused by annealing above 900 deg. C., is about the same as is shown in Table I.

Turning now to the thickest sheets (1.25 mm.), the results given in Table III show that there is a very substantial increase in the Erichsen value as the annealing temperature is raised from somewhere about 500 deg. C. to 650 deg. C. After this, however, the values remain almost constant until the $A_3$ point is reached at 900 deg. C., and even then the further improvement which occurs is relatively very small indeed.

## Effects of Annealing Temperature on the Tensile Properties

At first sight it might seem, from a more or less casual consideration, that it should be possible to form a comparatively accurate conception of the influence of the annealing temperature on the more important properties of the sheets. In certain respects the authors feel that such an inference might prove misleading. For although the Erichsen values may constitute a very useful guide by which to judge the relative merits of different sheets for the simpler kinds of dishing operations, there are other conditions under which they appear to be inadequate as a true indication of quality. Steel sheets are often found which give good Erichsen values, but which do not give satisfactory results in the seaming test, or when severely bent over a considerable length parallel with the direction of sheet-rolling, or possibly at right angles to that direction. The authors are of the opinion that this kind of anomaly seems to be more prononunced the thicker the sheets, and it may be largely due to the nature of the cupping test being such as to prevent the so-called grain effects of rolling becoming so manifest as they do when the sheets are subjected to a straight bend over a long distance.

It was with matters of this kind in mind, and also with the object of ascertaining the effects of the annealing temperature upon the grain of the steel, that the following preliminary survey of the tensile properties was made.

Before proceeding to describe what has been done in this connection, or to discuss the results, it may prove helpful to draw attention to certain peculiar features which have a special significance when dealing with the kind of material under consideration, and which should, therefore, be kept in mind when considering the results, for they tend to introduce greater irregularities in the tensile properties than are encountered when testing more massive materials.

In the first place, the chemical composition of the steel is such as to lead to more differential segregation than is the case with most steels. Further, the effects of this are much more intensified in sheets because of the thinness of the material being tested. Then, again, the character of the surface, especially as regards small defects and irregularities, is a factor which cannot be brought under rigid control, particularly when dealing with hot-rolled sheets. The treatment to which the material is subjected in the process of manufacture causes loss of carbon at and below the surfaces, and the extent to which this takes place varies considerably. It is also difficult to standardize the annealing experiments themselves in such a way as to get the same degree of carbon loss in all cases. Each of these variables might contribute to some extent to giving erratic final results, and it is, therefore, only to be anticipated that the values obtained will not show the same degree of consistency as is usually found when testing heavier material.

### General Summary

The influence of annealing temperature on the Erichsen values of a number of steel sheets varying in thickness and differing in composition have been determined. It is shown that the greater part of the rolling stresses left in the sheets from the hot-rolling mills were removed by annealing at temperatures of 625 deg. C. to 650 deg. C. In most instances a further substantial improvement occurred after the temperature was raised above the $A_3$ transformation.

Within these two limits of temperature, 650 deg. C. and 920 deg. C., the results obtained are, comparatively speaking, constant for each material. There are, however, indications in some cases that somewhat better results were obtained at 700 deg. C. than at any higher temperature up to 900 deg. C. This is certainly the case for sheets 0.5 mm. thick, and it is thought that the deterioration in the values, on raising the annealing temperature above 700 deg. C., was due to the coarsening of the ferrite crystals. It may be found possible to so adjust the period of annealing at about 700 deg. C. as to obtain small equiaxed crystals in the steel, and thus get results that will equal, if they do not surpass, any that can be obtained by annealing above the $A_3$ change point.

The authors anticipate that this will be possible only in those cases where the ferrite completely recrystallizes at the low temperature. The character of the pearlite or carbide of iron may have an important bearing in this connection. It is interesting to note that, with quite high phosphorus and sulphur contents in the steel, very good Erichsen values can be obtained by annealing at temperatures around 1,000 deg. C. In all probability this is due to the steel becoming more homogeneous as a result of the diffusion of phosphorus and the balling up of sulphide of manganese, in addition to the recrystallization that takes place on passing through the $A_3$ transformation. This view is supported by the fact that after the annealing temperature had been raised to 1,000 deg. C. closer agreement was obtained between the properties of the sheets when tested at right angles to the direction of rolling and parallel with that direction than for much lower temperatures.

A large number of tensile tests were made with sheets 0.5 mm. and 1.25 mm. thick. Perhaps the most interesting features revealed by these experiments are those relating to ductility. It was found that after annealing at about 700 deg. C. the elongations of the 0.4 mm. specimens, when tested in the direction of sheet-rolling, were considerably higher than when tested in the other direction; but the difference in this respect was small after annealing above 900 deg. C. Between the above-mentioned limits the curves show distinct minima corresponding with a temperature of about 800 deg. C. Quite tentative explanations of these phenomena are given. With regard to the 1.25 mm. specimen, the tensile properties were more regular when tested at right angles to the direction of sheet-rolling than when tested in the other direction, and, generally speaking, the elongation values were better in the former than in the latter case. Extremely low elongation results were obtained for this sheet when tested parallel with the direction of sheet-rolling after annealing at 900 deg. C. This indicates that the sheet-rolling had not been sufficient to eliminate or become equal to the grain effects in the original bar.

It may be of interest to note that the first marked break in the Erichsen values occurred between 625 deg. C. and 650 deg. C., whereas the corresponding break was shown up at about 600 deg. C in the tensile tests.

In conclusion, the authors would again like to make it quite clear that the work embodied in the present paper should be regarded merely as a general survey of the subject, and that it is already being extended in a number of directions.

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## Ohio-Cleveland Industrial Exposition

The metal trade will have a place in the epoch-making Ohio-Cleveland Industrial Exposition in Cleveland, August 6 to 28, commenserate with its dominating position in the industry of Cleveland and of Northern Ohio.

Practically every branch of the iron and steel and the nonferrous industry will be represented among the exposition exhibitors. Such nationally prominent concerns as the American Steel & Wire Company, National Malleable & Steel Castings Company, Pickands, Mather & Company, and a score of others will have displays of outstanding interest to all those connected with the steel and nonferrous industries.

For 23 days this great exposition will present a graphic picture of the industrial and civic greatness of Northern Ohio of which Cleveland is the metropolis and chief trading center. Industry will dominate the exposition by sheer weight of numbers and from the fact its 12,000 mills and factories pay 1,000,000 wage earners one and one-half billions of dollars each year for aiding in production of its six billion dollars of manufactured products.

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## Westinghouse to Supply American Rolling Mill Electrical Equipment

The Westinghouse Electric and Manufacturing Company has recently received an order from the American Rolling Mill Company for approximately $700,000 worth of electrical equipment. It comprises complete electrical equipment for a continuous hot-strip mill in the Middletown, O., plant and represents the most heavily powered continuous mill now running or under construction.

Included in the order are four a.c. motors totalling 3,800 hp.; eight d.c. motors totalling 18,150 hp.; six motor-generator sets, delivering a total of 13,800 kw., or approximately 18,500 hp., of d.c.; and a switchboard of approximately 120 panels to accommodate control apparatus.

# Safety Promotion in Western Pennsylvania

### An Interesting Outline of the Means Being Instituted for the Prevention of Accidents. Public School Children Educated in the Principles of Safety

**By JOHN A. OARTEL***

WHILE Pittsburgh has not yet reached the million mark in population, Allegheny County, which comprises the metropolitan area of Pittsburgh, has a population of a million and a quarter. The task of "Safetyizing" this "Mill Town" has been a man size job. It began actively in an organized way in 1917 when the Western Pennsylvania Division of the National Safety Council secured a salaried manager and went on record as the first local safety council to employ a paid worker. Since then things have been happening in safety in and around Pittsburgh with the result that we have begun to reap the fruits of our labors and the end is not yet. The full story of safety in Pittsburgh, which no man can tell, includes the industrial safety of the steel mills, manufacturing establishments, and mines, and the public and semi-public safety of the railroads, public utilities, department stores, trucking concerns, schools, and municipal and county authorities.

## Industrial Safety

Pittsburgh vies with Chicago in its claim as the birthplace of industrial safety. The point has never been settled conclusively, and probably never will be, but the fruits of the industrial safety have been gathered in a large way by the industrial plants of both cities and their environs until their proud boast, which has actually been proven, is, that it is safer to work in a steel mill than to walk the streets of a large city. This enviable record has been accomplished in Pittsburgh, as elsewhere, by organization, safe guarding, engineering revision, education, and co-operation. Space forbids going into detail and it is an old story, so one illustration will suffice. A large bar mill in the Pittsburgh district broke their tonnage record during January, February, and March, 1927, without a single lost time accident.

As an incentive to better results in industrial safety, the local safety council gives the Rice Safety Award yearly to the industry making the best showing. The award has been won by the H. H. Robertson Company, Beaver Valley Traction Company, and the Bell Telephone Company.

**Children from public schools of Pittsburgh who were awarded gold buttons by Western Pennsylvania Safety Council for saving lives of playmates or friends.**

The progress of industrial safety in the Pittsburgh district is shown in a remarkable way by the record of a large steel company which had 977 lost time accidents during July 1916 and 69 during July 1926, a reduction of 93 per cent.

## Public Safety

In describing the public safety activities of the local safety council only the high spots can be touched and this can be done best by citing the activities of a large public utility company which is a strong supporter of the council.

Some of the concrete ways in which this public utility company is endeavoring to keep the thought of safety before the public and its employes are as follows:

The maintenance of loading platforms for street cars.

Safety zones at car stops.

Inspectors to load and unload street cars during the rush hours at selected points.

Inspectors and trainmen to assist the city in the control and regulation of traffic.

Installation of car-berth signs which tend to lessen congestion and resulting potential accidents.

Painting markers on streets indicating car overhang and dangerous crossings.

Slow and stop signs at selected locations.

The new safety type car with its many safe features, such as, "dead man control" and car doors which must be closed before the car can be started and cannot be opened until the car has stopped.

The multiple unit train equipped with a self acting emergency brake in the event of trail cars becoming separated from the motor car on a grade.

The new low step.

Safety treads on car steps.

Improved designs on floor of cars, also improved head lights and fenders.

This company also maintains an accident location file whereby peak accident points are determined and the different accidents analyzed, as to the nature

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*President of the Western Pennsylvania Safety Council

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and particular points designated. Hazard points on any particular line are given to trainmen passing that point. The information is also turned over to the traffic engineer of the City of Pittsburgh for further analysis and recommendation as to cornermen and the installation of safety equipment. The City of Pittsburgh also studies street accidents in this manner, co-operation being thus developed in minimizing automobile accidents.

### Teaching Safety in Schools

The contact with the schools of the Pittsburgh district has shown very fine results. Representatives from the public and parochial schools are members of the board of directors of the safety council and a special committee of school principals executes the work in detail. Junior safety councils have been formed in 90 of the public schools in the City of Pittsburgh with approximately 20,000 members. This work is now being extended to Allegheny and surrounding counties. A rally of the officers of the junior council was held at the Davis Theater, Pittsburgh, May 21, 1927, attended by 2,000 pupils who brought with them their flags, banners and yells. At this meeting gold buttons were presented to 13 children who had saved the lives of playmates or friends.

Since 1917 when the local safety council first employed a paid manager, 35 safety lecture courses have been conducted in Western Pennsylvania with 398 meetings, 788 speakers and an attendance of 227,000 superintendents, foremen, workmen, and motor drivers.

Two special activities of the local council, which gives promise of becoming permanent are, "Brake Test Week" and "No Accident Month." The last "Brake Test Week" was held in June, 1926, when the brakes of 20,000 cars were tested and a third of this number were found to be defective, being in need of either lining or adjustment. Five stations were manned by 33 workers whose services were donated by member companies and the police department of the City of Pittsburgh. The workers consisted of 15 policemen, 12 mechanics and 6 checkers. The windshield stickers given to the motorists and truck drivers whose brakes passed the test are kept on the windshield for an indefinite period. The car owner takes a justifiable pride in displaying this sticker and they are also a warning to the driver who neglects to give his brakes the proper care.

A number of " Safety Weeks" have been conducted by communities in recent years, but it is doubtful if a "No Accident Month" has ever been conducted on such a large scale covering so large a territory and with such gratifying results as the "Thanksgiving No Accident Month". conducted by the Western Pennsylvania Safety Council during November 1925 and November 1926. Industries, public utilities, schools, stores, clubs, churches, and city, borough and county officials all supported and took part in it.

"Safetyizing" a "Mill Town" which is a designation Pittsburgh is proud to acknowledge is a "he-mans" job. The results accomplished have been secured by wise, efficient and consecrated leadership in the local safety council and hearty co-operation from the membership. We do not yet boast of having the safest big city in the country, as we are merely on the way to yet greater accomplishments to the end that our mills, our streets, our highways, our schools, and our homes may be free from accidents.

## Freyn Engineering Company Secures Foreign Contracts

Henry J. Freyn, president of Freyn Engineering Company, Chicago, returned a short time ago from a five months business trip to Europe, having spent two and one-half months in Moscow to negotiate and close with the Soviet Government a consulting engineering contract for the Russian iron and steel industry.

On his way back to the United States, Mr. Freyn stopped in Germany, Luxembourg, Holland and England. While in Germany Mr. Freyn assisted his company's associates, Gutehoffnungshutte, Oberhausen, Rheinland, in negotiating for two contracts on which Freyn Engineering Company will do the engineering. One is for the remodeling of the Dudelange Blast Furnace Plant of the Acieries Reunies de Burbach Eich Dudelange, Luxembourg, and the other for a blast furnace plant comprising two stacks of American design for the Mannesmann Tube Works, Huckingen, on the Lower Rhine.

In addition, Mr. Freyn made arrangements with the United Steel Works of Germany for consulting and designing engineering in connection with a new blast furnace plant at Duisburg.

## Increase in Electricity Used

The monthly report of the production of electricity by public-utility power plants for May, issued by the Geological Survey, Department of the Interior, shows a total for the first five months of the year amounting to 32.4 billion kwh., or about 9½ per cent more than the output for the same period in 1926. An estimate based on the output so far this year and on comparable figures for 1926 indicates that the total output for 1927 will be in the neighborhood of 80 billion kwh. The total for 1926 was 73.8 billion kwh.

The effect of the increasing hours of daylight and the rising temperature from the first to the middle of the year on the demand for electricity for light and heat is shown in the decrease in the average daily production of electricity that occurs during this period each year. This year the decrease in the average daily output from January to May was about 3 per cent; in 1926 the decrease was about 5 per cent; in 1925, 6 per cent. The lessening of the decrease in 1927 may be due, in part, to the increasing load for electrical refrigeration.

The average daily production of electricity by the use of water power in 1927 has set a record for each month from March to May. As the amount of electricity produced by water power is directly dependent on the amount of water flowing in the streams used for the development of power, it is expected that the output will begin to decrease after the month of May, as March, April, and May are generally months of maximum flow for streams in the United States.

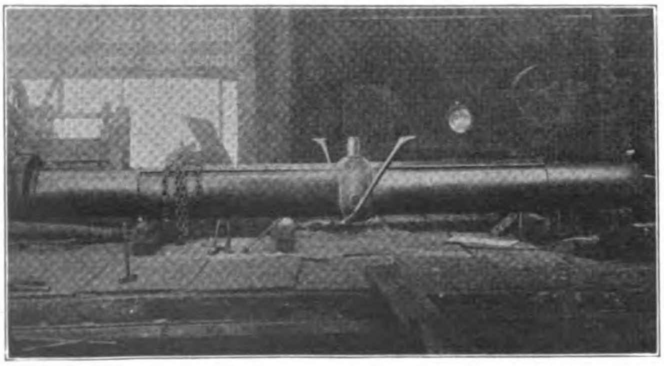
Notwithstanding the record-breaking output of petroleum this year, the consumption of fuel oil by public-utility power plants has decreased each month, and the consumption in May was less than in any other month since the Geological Survey began to publish monthly power reports in 1919.

# Thermit Welding in the Steel Mills

## Manner of Welding by Which Repairs Can Be Quickly and Economically Made. A New Method Involves a Very Considerable Saving Over One Formerly Employed

IN the steel mill, where it often used to be more economical to replace a broken part, the welding process has now become so economical that welding reclamation departments are being organized in plant after plant, and one plant alone of an important steel company employs a large force of men for this work, using almost 100,000 lbs. of Thermit per year and is making very large savings. The work is done on all iron and steel sections, including table rolls, rolling mill housings, blooming engine parts, crankshafts, connecting rods, charging peels, etc. A great deal of work is also done, by the use of a special Thermit in replacing the wear on wabblers and the metal can be so accurately added as to require no machining and is so hard as to be just barely machineable and resists wear indefinitely.

The new improved method of making the weld, developed and patented after a very extensive research and which has been in use during the past year is an important economic factor in reclamation work. This new design enables a weld to be made with less than half the amount of Thermit previously required and this, in turn, permits the use of smaller mold boxes, less molding material, quicker ramming of molds, less labor, and smaller crucibles. The change in the crucible cost is an important item when it is realized that a crucible to contain a steel of over 5,000 deg. F. must be very carefully made and because most of the refractories dissolve to some extent in steel at this temperature, the highest grade, dead burned magnesite must be used. A crucible lining of this magnesite lasts in the case of small crucibles for 40 or 50 reactions, but in the case of large crucibles holding 600 or 700 lbs. of Thermit, the lining lasts for only four or five reactions. The new methods have made this crucible problem much less important because in the big welds where two or more crucibles were used, only one is now necessary, and, where one large crucible was previously used, a much smaller one can now be used, the smaller one costing less in the first cost and much less per reaction because of its longer life.

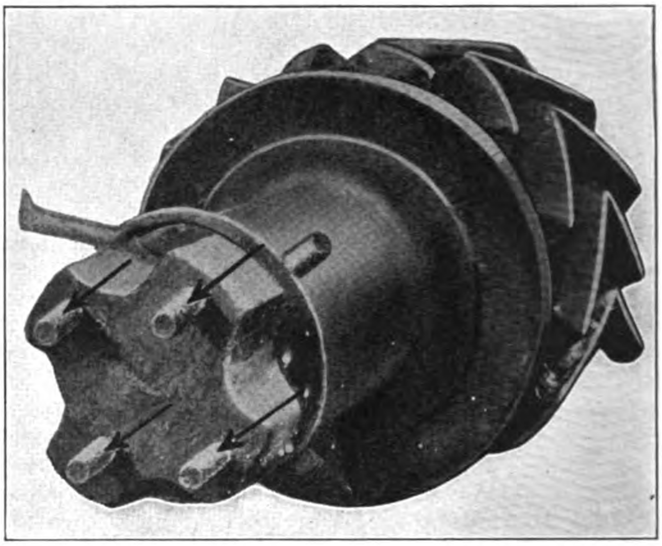


26-in. diameter blooming mill shaft welded in 48 hours.

The great saving possible in the new method over the old can be readily appreciated by comparing a typical thermit welding operation on an 8 in. diameter shaft as carried out by the two methods:

| | Old Method | New Method |
|---|---|---|
| Pounds of Thermit required...... | 155 | 65 |
| Width of Thermit steel collar.... | 7 in. | 4 in. |
| Thickness of Thermit steel collar.. | 1⅝ in. | ⅞ in. |
| Diameter of riser ............... | 4½ in. | 2 in. |

The difference in the final cost, which involve the cost of the Thermit, the crucibles and the pounds of wax required in making the mold, shows a saving of approximately 60 per cent by the new method. This percentage does not include the items of the smaller amount of molding material used, less labor required and the time saved.



**Four pods built up before machining—During 1926 one steel mill report showed that over 200,000 tons of steel were rolled, with a pinion of this description on which new ends were welded.**

The process in its present and highly efficient stage of development offers convincing proof of the great savings possible in reclaiming broken steel mill parts involving heavy sections, and the importance of organizing a reclamation department in the steel mills cannot be denied recognition.

## River Shipments Unusually Large

An unusual occurrence on the rivers this month will be the movement from Pittsburgh to Southern river ports of a large tonnage of steel products sent out by the Jones & Laughlin Steel Corporation.

The river movement by Jones & Laughlin will consist of a total of 10 steel gondola and box barges loaded with various steel products for customers in the South and Southwest, which will go down river within the next few days. There will be several barges of steel pipe for the oil fields of Texas, Wyoming, and Arkansas, and wire fence for delivery at Memphis.

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# The POWER PLANT

# A Century and a Half of Stokers

### Successive Improvements in Stoker Construction Are Recited from the Earliest Design. Underfed Type Receives Special Consideration. Requisites Tabulated

OF all our natural resources, coal is probably the most important. It is the material source of all energy and a factor in everything we do. Our whole industrial world is dependent upon it, not only from a fuel standpoint, but also from the standpoint of its many by-products, such as drugs, chemicals, explosives, flavoring extracts, perfumes, road building material and paints. Hardly anything we can name but what in some stage of its history is linked with coal. Without coal there would be no steel industry. Without steel we would have no railroads, telegraph, telephone, big buildings, bridges or other modern conveniences which we, without a thought, accept as part of our everyday life.

The transformation of the heat energy of the coal into useful work is a problem which mankind has been trying to solve for generations. The development of the stoker is a direct result of the attempt to solve this problem and is an interesting story.

Many myths attempt to explain the origin of the but as far back as there are any records, fire was known to the earliest inhabitants of the earth. True, it was not fully understood nor did man appreciate his power to control it. He only knew it produced light and heat and possessed the power of inflicting pain or even death. Because he did not understand it, man stood in awe of its wonderful power and even worshipped it as a god. Many weird superstitions, which with our present knowledge seems absurd, are traceable to the homage paid this god of fire by our savage ancestors.

As culture and civilization developed, we find a greater appreciation of the value of fire, especially in producing heat and in the preparation of food. Gradually, as man came to better understand the natural laws of fire and appreciate his power of controlling it, its uses increased until today it would be absolutely impossible for civilization to exist without fire.

The first fires, of course, were built directly on the ground or hearth. Then it was found that raising the bed of fire to allow the air to pass through it caused the fire to burn better. From this came the evolution of the hand fired grate which for a long time met all requirements.

With the invention of the boiler came the necessity of providing proper means for firing it. The application of the hand grate was the most natural thing, but when burning bituminous coal, the furnace became exceedingly smoky.

## Stoker Invented by James Watt

James Watt, inventor of the steam engine, studied the problem and finally developed and patented, in 1785, a stoker, Fig. 1, designed primarily to overcome smoking. It was a simple device designed to push coal, after it was coked at the front end of the grate, back towards the bridge. It was worked intermittently by levers.

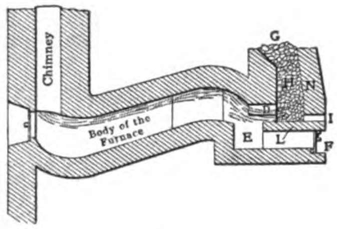
With hand fired grates it is the custom for the fireman to shovel in a quantity of coal and then rest. With the increased use of boilers it became evident that better results could be secured if the coal was burned at a uniform rate. This meant that the firing must be done in very small quantities or continuously.

A recognition of this requirement turned attention toward developing some mechanical means for introducing coal into the furnace. In 1819, William Brunton, Birmingham, England, patented a mechanical stoker. It consisted of a circular grate revolving on a central vertical spindle, and a hopper with toothed roller so placed as to discharge coal upon the slowly revolving grate.

John Stanley's idea of introducing the fuel into the furnace was somewhat different, and in 1822 he patented a stoker consisting of a hopper at the front of the boiler, with crusher rolls, and rapidly revolving fans for distributing the coal over the grate. Some years later, E. Hendersone patented a stoker very much the same, except that he used shovels actuated by springs for distributing the coal over the grate. In passing, it is interesting to note that these two stokers contain the fundamental idea on which the present locomotive stoker is built, although steam is used as the distributing means.

Until 1822, the principal consideration had been to feed the coal into the furnace uniformly. Little attention was paid to the manner in which it was burned and practically no attention to providing means for the removal of ash and refuse from the furnace. These three fundamental considerations are basic for any stoker.

In 1834, J. G. Bodmer began to give more consideration to the basic principle of providing means for ash removal. He developed a stoker in which the coal was fed from a hopper onto an ingeniously designed grate, in which the fire bars were slowly moved inward, and on reaching the bridge, were dropped in sections, and returned to the front of the stoker by means of return screws. This device was too complicated to be practicable, but in 1841, John Jukes brought out a stoker embodying this same idea, Fig. 2. It consisted of longitudinal firebars connected by links so as to form an endless chain. The small coal was delivered from a hopper on the front of the boiler onto the grate. The grate moving slowly from front



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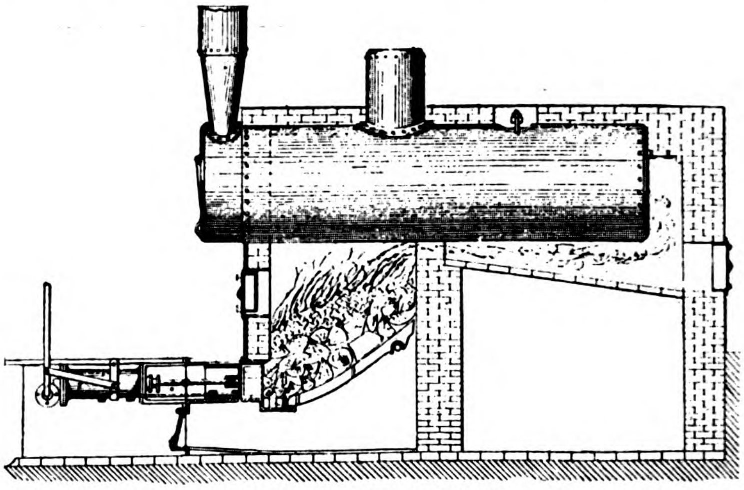

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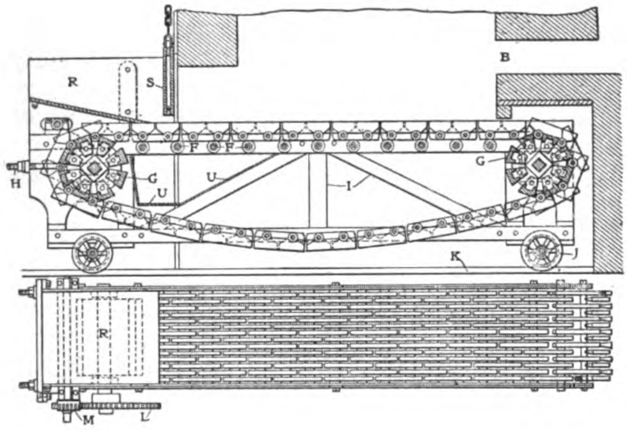

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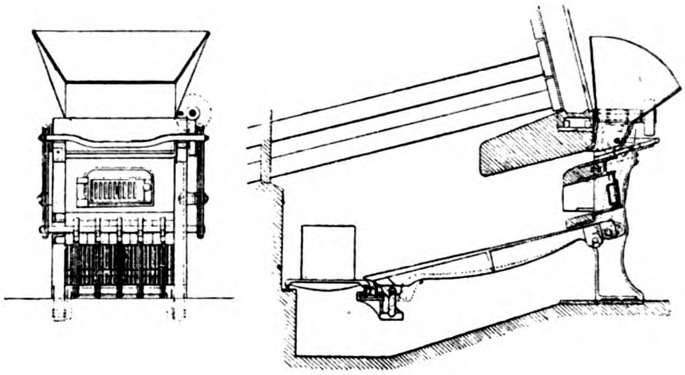

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FIG. 1—Watt stoker. FIG. 2—Jukes stoker. FIG. 3—Jones stoker. FIG. 4—Knapp stoker.

to rear advanced the fuel into the furnace and discharged the ash and clinker at the rear. This stoker is interesting, in that it is the forerunner of the modern chain grate.

Another group of inventors felt that the fuel could best be advanced through the furnace by a stoker in which the firebars were arranged lengthwise of the furnace and were given a slow reciprocating motion. The Knapp stoker embodies this feature, Fig. 4.

Another means of introducing the coal into the furnace was brought out in the Holroyd-Smith stoker, in which a sort of screw type conveyor was used.

Up to this time in England, the predominant type of boiler was the internally fired boiler; hence the majority of stokers were suited only for that type of boiler. In America the majority of boilers were externally fired. This imposed still another condition for the stoker designer to meet.

### The Murphy Stoker

Thomas Murphy of Detroit, Mich., was the first to bring out a stoker distinctly American and arranged for externally firing a boiler, Fig. 5. In his furnace, patented in 1878, he provided for the distribution of coal over the grates, the access of air to the coal through the grates, and the discharge of the ash and refuse from the grates. That the stoker was fundamentally correct, is evidenced by the fact that it is still built with but very few changes.

Not a great deal of attention had been paid to the arrangement of equipment in boiler houses up to that time. As the size of boilers began to increase, it became apparent that the arrangement should conserve space and yet be convenient for getting coal to the boilers and the ashes away from them. In addition, all equipment should be accessible as possible, both for operation and maintenance. With this in mind, W. R. Roney developed the Roney Mechanical Stoker in 1885, just 100 years after Watt invented his stoker, Fig. 6. The coal is fed to the stoker from a hopper at the front of the stoker instead of at the sides, and travels over rocking grates to the dump grates, where the ash and refuse is deposited. This stoker is still built and sold today. For the class of application to which it is suited, it is an excellent stoker.

In 1888, Evan Williams Jones, an engineer in Portland, Ore., was engaged by a firm to design a furnace and grate for burning fir wood. This fuel ignited very slowly, due to the fact that it contained a very large percentage of moisture. Jones conceived the idea of introducing the wood underneath the active fuel bed, so that the moisture could be evaporated before the wood actually began to burn. Modified slightly, this same stoker was used for burning coal, Fig. 3. There was brought out this experiment, the fundamental principle underlying the present Underfeed stokers, namely, that of feeding the fuel from the underside of the fire and introducing air for combustion above the green fuel but just below the incandescent fuel bed. With but very few changes, the Jones stoker is still made and sold.

With the advent of the steam turbine, the amount of steam required from the boilers increased enormously, due to the much greater capacity of turbines over reciprocating engines. Boilers had to be operated at higher ratings. Stokers adequate for old requirements became obsolete. To meet the new conditions meant larger grate surface or devising some means for burning more coal per square foot. Smoke, too, was becoming more and more objectionable, especially in large industrial cities where the concentration of population was rapidly increasing.

### Taylor Conceives Underfed Principle

In 1901, Elwood Taylor conceived the idea of using several retorts placed alongside of each other and developed the Multiple Retort Underfeed Stoker, Fig. 7.

Until 1914, efficiency of combustion had not assumed much importance. The rapidly rising price of coal, however, brought this factor into prominence and although no change in the fundamental principle of Underfeed stokers has been made, remarkable progress in increasing the combustion efficiency must be acknowledged.

The rapid development of boilers, particularly in the large sizes, and high capacity operation has continuously pushed up the required combustion rate per square foot of grate surface, making the early types of stokers totally unsuited for the work. Minor modifications have adapted the Underfeed stoker to this work when burning all kinds of fuel.

The trend of development in industry has a distinct bearing on the development in any one particular line of industry. Impetus is given to those endeavors which trial and experience prove to be worth while. Frequently, as development progresses, the requirements multiply and become so exceedingly complex that the main objective is obscured. It is then that lack of co-ordination creeps in and destroys the value of the endeavor. It is constantly necessary to bear in mind the fundamental requirements upon which an endeavor is based.

### Fundamentals for Ideal Stoker

Three fundamental things are required of an ideal stoker:

1—Induct the fuel into the furnace.
2—Burn the fuel efficiently.
3—Remove the ash and refuse from the furnace.

Corollary to the first requirement are the following:

1—Feed fuel uniformly and distribute it evenly over the grates.
2—Large reserve overload capacity.
3—Simplicity of construction.
4—Ruggedness and durability.
5—Protection of fuel feeding mechanism from excessive heat.

Corollary to the second requirement are the following:

1—Handle successfully a wide variety of fuels.
2—Simplicity of operation.
3—Proper proportioned and distributed air supply.
4—Smokelessness.
5—Adequate agitation of fuel bed.
6—Durability and accessibility of parts exposed to fire.

Corollary to the third requirement are the following:

1—Simple means of ejecting ash and refuse quickly.
2—Easily adaptable to an ash conveying system.

The co-ordination of these requirements and their incorporation into a stoker represents a period of study and research covering a term of years. Frequently, an apparently minor factor proves very troublesome, and considerable effort is required to arrive at the solution required. Each feature therefore has its own individual history and reason for being in the stoker.

In the stoker illustrated in Fig. 7, the slope of the rambox is the same as that of the retort, so that gravity assists in the feeding of the coal into the stoker and the wear on the rams and ramboxes is lessened. As the coal is pushed in by the ram it enters the retort throat. The retort throat is designed with a special contour of flaring, diverging sides extremely effective in spreading the fuel over the tuyere rows, immediately and uniformly. Ample reserve capacity for any emergency is available.

The construction of the stoker is based on the unit retort. The retort side plates, cast in three or more sections, are assembled with splice plates on structural angle iron supports. The tuyeres are then assembled on adjacent sides of unit retorts which are properly spaced by spacing bars. Retort parts are assembled between the retort side plates. All drillings are made to jigs so that all castings of any particular part are interchangeable. The addition of the rambox completes the unit retort assembly. The ruggedness and simplicity of this type of construction are very striking.

All of the coal feeding mechanism being without the furnace is protected from excessive heat.

Sufficient adjustments have been provided so that any kind of fuel may be burned. Group control of operating adjustments simplifies operation.

### Air Distribution

To secure the proper proportioning and distribution of air, the tuyeres are of special design. Peripheral corrugations form the openings through which the air is emitted and in addition, provide a maximum of radiating surface for cooling the castings. The openings are graduated to supply a greater amount of air over the retorts than over the tuyere rows. To insure the complete combustion of the volatile gases and prevent front wall erosion, air is introduced over the fire through air distributing boxes. These are built separately from the front wall support casting, and air is circulated through them for cooling the casting. The brick front wall rests upon the support casting which is always thoroughly protected from the fire by the air distributing box. The air distributing box being entirely independent of the front wall support may be renewed without disturbing the front wall.

The complete combustion of the volatile gases obtained by introducing air over the fire is most effective in preventing smoke.

Adequate agitation of the fuel bed is provided for by the secondary ram and the agitating dump grate. The adjustment for change in length of stroke is by group control.

The agitating dump grate is shown in its normal position. For agitating the lower portion of the fuel bed it is raised to a horizontal position by a power cylinder with a quick motion. Ordinarily, only the rear dump grate is used for dumping, the front one

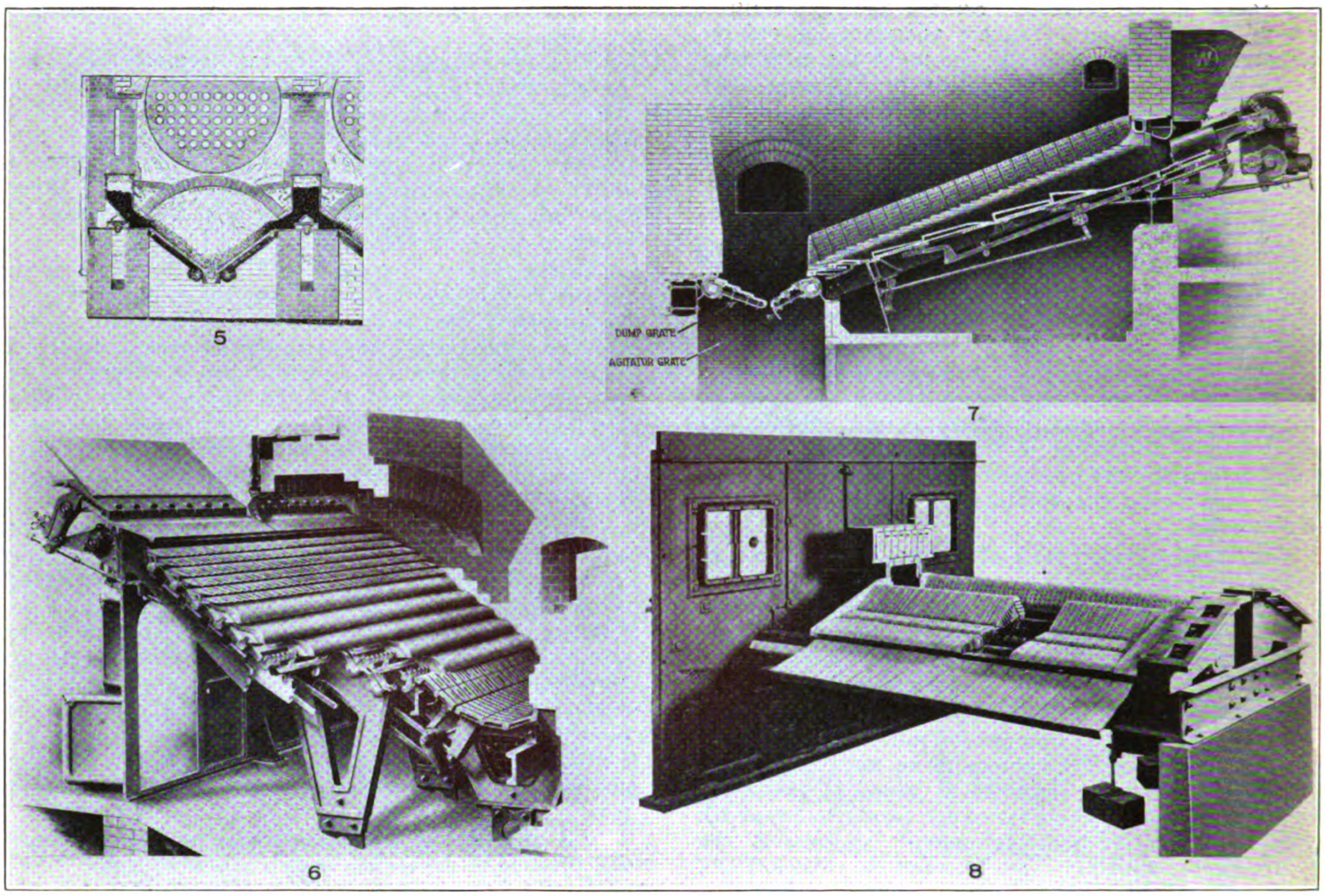

FIG. 5—Murphy stoker. FIG. 6—Roney stoker. FIG. 7—Multiple retort stoker—Dump grate type. FIG. 8—Westinghouse single retort stoker.

being held in its horizontal position to prevent avalanching of coke into the ash pit. In emergency, both grates may be opened wide to discharge clinker of large proportion. For the discharge of ash and refuse continuously, the stokers are now equipped with clinker grinders. The vertical walls of the clinker grinder pit make certain the uniform flow of ash and refuse to the grinder rolls.

The formation of clinkers along the sidewalls of the furnace has been overcome by the use of sidewall extension tuyeres. Air is emitted from openings in the plates, cooling the castings and thoroughly oxidizing clinker forming material.

### Drives for Stokers

Multiple Retort Stokers are usually driven by steam engines or motors. Steam engines because of the low speeds obtainable are frequently direct connected to the stoker lineshaft. If not direct connected, a chain drive is used. Motors, on account of the higher speeds, are in nearly every case connected to the stoker by chain or by some speed reduction device. Occasionally one sees an external turbine drive, also connected through a speed reducing device.

For boilers up to about 500 hp. where the duty required of the stoker is somewhat less than would warrant the expense of a Multiple Retort Stoker, the Single Retort Underfeed Stoker makes an ideal application, Fig. 8. It is, in a sense, an intermediate between the Overfeed Stoker and the Multiple Retort Stoker. This stoker is capable of moderately high ratings with correspondingly high efficiencies and is quite simple mechanically. As the coal is fed into the retort by the main ram, it is forced over the retort sides where it is picked up by undulating grate bars and carried laterally to the dump grates.

The most important features of this stoker is the grate motion, mechanically created and controlled. "It's the grate that burns the coal." The retort is a distilling zone and the dump grates are for receiving and discharging ash. Therefore, the effective burning of the fixed carbon must be accomplished between the retort and the dump grate. Coal lying inert does not burn well. Agitation is needed to keep the fuel mass porous so that the air for combustion may be thoroughly distributed and so that large unwieldy clinker formations do not occur. Furthermore, without a grate having motion under control, it is impossible to regulate the fuel bed to meet changing conditions.

## General Electric Sales

General Electric Company sales billed for the first six months of 1927 announced today by President Gerard Swope amounted to $149,795,026.99 compared with $147,450,867.96 for the corresponding period last year. Profit available for dividends on common stock for the six months of 1927 was $22,542,972.76 compared with $19,000,392.63 for the same six months last year.

# Feed Water Heaters and Their Uses*

### A Survey of the Conditions Under Which Heaters and Economizers Are Justified. Savings to Be Obtained. Types of Heaters and Their Application

THE chief use of feed-water heaters is to return some of the heat passing out of the power plant with the exhaust steam to the boiler, and thus save the amount of fuel that would be used in heating the feed-water through the range which the exhaust steam, or sometimes the flue gas, will raise it.

A writer in the "Power House" points out that the heating of feed-water has the following advantages to recommend it: First, increase in boiler capacity, because the heat that would be required to heat the incoming water can be used to make more steam; second, in heating feed-water, certain of the most troublesome scale-forming impurities are thrown out of solution, and if a filter or settling tank is provided between the heater and the boiler, these impurities are prevented from going into the boiler; and third, by feeding the water into the boiler nearly at steam temperature, strains in the boiler shell, due to unequal temperatures of different parts, are avoided.

The saving of fuel due to heating the feed-water can be conveniently calculated in percentages by using the following formula:

$$\text{Per cent saving} = \frac{t_2 - t_1}{H - (t_1 - 32)}$$

where $t_1$ = the temperature of the entering water, $t_2$ = the temperature of the water leaving the heater, and $H$ = the total heat above 32 deg. F. of the steam, as supplied by the boiler.

For example: Suppose fresh water is available at 42 deg. F., and the heater raises it to 202 deg. F. before entering a boiler generating dry steam at about 100 lb. gauge pressure. From the table of properties of saturated steam it will be found that the total heat of steam is about 1,191 btu. per lb. Substituting in the formula we get:

$$\text{Per cent saving} = 100\,\frac{202 - 42}{1191 - (42 - 32)}$$

$$= 100\,\frac{160}{1181} = 13\tfrac{1}{2}\text{ per cent.}$$

## Classification of Heaters

Feed-water heaters may be classified into three main groups—viz., closed heaters, open heaters, and economizers. The first two groups use steam, either exhaust or live, as the heating medium, while economizers make use only of the waste heat in the flue gases.

Closed water heaters are distinguished by the fact that the water, and the steam doing the heating, are kept out of contact with one another; thus they may be at different pressures if desired. Closed heaters are commonly placed on the boiler side of the feed-pump. In this location the water pressure is high, and the temperature is high, and the temperature can be raised much above 212 deg., which not only assists in relieving temperature strains in the boiler, but precipitates many of the impurities which would remain in solution at 212 deg.

When a closed water heater is made use of to extract some heat from the steam exhausting from a condensing engine at very low pressure, it is located between the engine and the condenser inlet, where it not only regains some of the heat that would be wasted in the hot well, but reduces the size of the condenser and the amount of circulating water required.

In this location it is known as a vacuum heater, because of the pressure of the steam, while the water may be at any pressure convenient.

Closed heaters are classified as steam-tube and water-tube heaters, the names indicating whether the steam or the water passes through the tubes while the other circulates around the inside of the shell among the tubes. Both types may be built as parallel-flow, in which the steam and water flow in the same general direction, or counter-flow, in which the reverse is the case. The latter is generally more efficient than the former if it is at all possible to connect that way. They may also be made in single-pass or multi-pass type, where the steam or water, or both, may make a direct route from inlet to outlet, or may be forced to pass back and forth through different parts or sections of the heater several times. The usual practice is to make one of the fluids make two passes while the other makes a single pass. Only in complicated plants are more passes used.

The tubes are secured to the tubeplates by welding, screwing, or expanding, or they may be held in place by ferrule glands to simplify renewal and allow some expansion and contraction. Where ferrules do not allow for expansion of the tubing, the tubes are either of a U-shape, fixed at only one end, or they may be fixed solidly at one end and attached to a floating head at the other end, which can move back and forth in the shell of the heater as expansion and contraction take place. They may be installed either horizontally or vertically.

Closed heaters require little attention except where the water and steam are under widely different pressures, when leakage must be prevented, or when high temperatures are used the accumulations of scale-forming matter must be removed in order to keep the tube surface clean for transmission of the maximum of heat.

## Open Heaters

Open heaters are of three different types: First, that known as the live-steam heater, the sole purpose of which is to heat the feed-water up to approximately boiler temperature by the addition of live steam at boiler pressure, thus settling out many of the scale-forming impurities; second, that used at atmospheric or lower pressure; and third, that used with exhaust steam at low pressures up to 10 or 20 lb. per sq. in., where the engine exhaust may also be used for process work or building heating.

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*"Mechanical World," July, 1927.

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In the common type of open heater the exhaust steam, after passing through an oil separator, enters the shell near the top at one side. The cold feed-water enters at the top of the shell, and passes over and through a set of perforated trays, where it is divided into fine layers or streams, thus coming in intimate contact with the steam throughout, condensing the steam and flowing as hot water to the bottom of the shell through a bed of filtering material.

A float is provided to control the amount of fresh water admitted, so that it is always at the same level.

In the event of anything happening to this float mechanism there is an overflow provided, in order that there will be no danger of water backing up into the exhaust line.

Since the amount of heat given up by the steam equals that absorbed by the water, plus the loss by radiation, the amount of steam required to raise water through a given temperature is easily calculated. Likewise the resulting feed-water temperature is easily estimated when the quantities of steam and water and the initial temperature of the latter are known.

The radiation losses are negligible in the above calculations if the heater is properly insulated. Formulae for such purpose may be used in the following form:

$$S = \frac{t_2 - t_1}{H + 32 - t_1}$$

and

$$t_2 = t_1 + \frac{(H + 32 - t_1)\,S}{},$$

where S represents pounds of steam per pound of water; H represents total heat of exhaust steam per pound; $t_1$ represents temperature of cold water to heater; $t_2$ represents temperature of hot water to boiler.

| | OPEN HEATER | CLOSED HEATER |
|---|---|---|
| **Efficiency** | | |
| | With sufficient exhaust steam for heating, the water can reach the temperature of the entering steam. Scale and oil do not interfere with its operation. | The maximum temperature of the feed-water will always be below that of the steam. If scale or oil is deposited on the tubes, efficiency is reduced. |
| **Pressures** | | |
| | Usually operates at or near atmospheric pressure. | Water pressure may be slightly greater than boiler pressure, which is usual. Steam pressure may be anything from boiler to vacuum pressure. |
| **Safety** | | |
| | If the heater is to be used with a back pressure, a good multi-disc back pressure or reilef valve should be fitted. | Safe at ordinary pressures, shut-off valve on pump-line should be between pump and heater, with check between heater and boiler. |
| **Purification** | | |
| | Special provision must be made to separate oil from the exhaust steam, as it mingles with the feed-water. Scale-forming impurities are precipitated in the heater, where they do no harm and are easily removed. | The oil does not come in contact with the feed-water. Scale formed on the tubes is difficult of removal. |
| **Corrosion** | | |
| | The open heater helps to prevent corrosion by driving off oxygen originally contained in the water. | The oxygen is not discharged from the closed heater, but passes into the boiler, where it causes corrosion. |
| **Location** | | |
| | Must be placed higher than the pump on the suction inside. The greater the vertical distance between the heater and pump the better. | May be placed in any position on the pressure side of the pump. |
| **Feed-Pumps** | | |
| | With supply under suction, two pumps are necessary, and one must handle hot water. | Only cold water feed-pump is necessary. |
| **Adaptability** | | |
| | Particularly adapted to heating systems, and wherever returns are piped direct to heater. | Adapted to use in small space, and when condensate of exhaust steam can be used in process work. |

### Selecting Open Heater

In selecting an open heater the following features should be considered:

1—Size: Must have sufficient steam space and tray area.

2—Filter bed: This is sometimes omitted, but should be used to remove any last traces of oil, as well as the impurities precipitated by the heating.

3—Hot well: The space at the bottom should be large enough to act as a settling basin, and a storage supply of hot water for sudden feed requirements.

4—Automatic water inlet valve: This should always be part of open heater equipment.

5—Overflow, and pressure relief valves.

6—Meter: In some styles of open heaters a meter is incorporated in the design as an automatic feed-water measurement.

The relief or back-pressure valve for heaters operating above atmospheric pressure should be adjustable, in order that the engines may not require to work against greater back pressure than necessary when large quantities of heat are not required.

### Choice of Type

The general construction of the power plant usually determines the type of heater to be used. For example, in marine service closed heaters are preferable because of the rolling of the ship, space limitations, and scarcity of fresh water at sea. Open heaters are, however, adapted for marine use, though not so common in this service as the closed types. Closed heaters are sometimes used in ice plants when the condensate is used for ice making; better ice, however, is generally obtained where open heaters are used, because the air is driven off from the feed-water instead of passing through the boiler and engines.

A comparison of the two types is tabulated herewith.

### Economizers

The economizer is a closed feed-water heater located in the smoke flue to utilize some of the heat of the waste gases of combustion. Economies are becoming increasingly popular as the cost of fuel rises, especially in view of the high temperatures at which the gas leaves the boiler at high rates of combustion.

Economizers are of two general types, the separate economizer and that which is integral with the boiler,

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although the latter class is not always called by that name. For example, the back-pass of the Stirling boiler is in reality an economizer.

Because the water in an economizer is much cooler than that in the boiler there is a possibility of moisture, or when the coal contains sulphur, sulphuric acid vapor condensing on the economizer surfaces causes severe cases of corrosion. For this reason economizers should be made of cast iron, or, if of steel, should be protected from corrosion. Integral economizers are almost invariably made of steel tubes and drums as a part of the boiler.

One of the commonest forms of separate economizers is built of cast-iron tubes pressed into cast-iron headers. The tubes are mounted vertically in the flue leading from the furnaces to the chimney. Either scrapers or soot-blowers must be provided to keep the tubes clean, or accumulations of soot and dust soon lower the heat-absorbing power of the tubes. The scrapers are generally operated by a motor or engine all the time the plant is operating. The feed-water enters the bank of tubes at the bottom nearest the chimney and leaves at the top nearest the boiler.

To be effective in noticeably raising the feed-water temperature, economizers must be large and costly. When only light loads are carried the saving is insufficient to warrant the cost of the installation. When large overloads are being carried the gas rushes through the boiler passes more rapidly, and is therefore not cooled down to the same extent.

It is under such conditions, when the flue gas is at a high temperature, that economizers are warranted.

## Grid Glow Tube Inventor Awarded John Scott Medal

The John Scott medal, given annually in recognition of "useful inventions for the use and benefit of mankind," has been awarded to D. D. Knowles, 28-year-old inventor of the Grid Glow Relay. Notice of the award, which carries a cash prize of $1,000 was given by Walter R. Russel, acting secretary. Presentation will be made at a later date.

Mr. Knowles perfected his invention in the research laboratories of the Westinghouse Electric & Mfg. Company. His grid glow relay has been acclaimed as the most sensitive current-controlling device ever developed. The glow tube, which functions on a billionth of a watt, is set in operation by such tiny impulses as the mere approach of the human hand, a drop of water or the light of a match.

The fund for the award was established in 1816 by John Scott of Philadelphia. Five other scientists were similarly awarded this year.

They are: Stickland L. Kneass, Philadelphia engineer, for the invention and development of an exhaust feed water heater injector; Dr. Afranio Do Adaral, Bahia, Brazil, for his preparation of anti-snake-bite serums; Dr. Alfred Fabius Hess, professor of children's diseases at Columbia University, New York, for his studies on the influence of ultra-violet light on rickets and on various foods, showing that the vitamin values in these substances could be increased; Herbert E. Ives, physicist, Bell Telephone Laboratories, New York, for development of a method for transmitting pictures over telephone lines and for further development of television.

## COMING MEETINGS

Aug. 31-Sept. 2—Steel and Power Show. Exposition at University of Toronto Arena, Toronto. C. Bradshaw, chairman, 153 University Avenue, Toronto.

* * *

Sept. 6-9—New Haven Machine Tool Exhibition. Annual exhibit at Mason laboratory, Yale University, New Haven, Conn. H. R. Westcott, chairman, 400 Temple Street, New Haven, Conn.

* * *

Sept. 15—American Refractories Institute at the Clifton Hotel, Niagara Falls, Canada. Headquarters, 2202 Oliver Building, Pittsburgh, Pa.

* * *

Sept. 12-17—International Congress for Testing Materials. Meeting at Amsterdam, Holland. Headquarters at Valckenierstraat 2, Amsterdam, Holland.

* * *

Sept. 19-22—Society of Automotive Engineers. Production meeting at Hotel Winton, Cleveland, Sept. 19-20 and Hotel Statler, Detroit, Sept. 21-22. Coker F. Clarkson, secretary, 29 West Thirty-ninth Street, New York.

* * *

Sept. 19-22—American Welding Society. Fall meeting at Book-Cadillac Hotel, Detroit. M. M. Kelly, secretary, 33 West Thirty-ninth Street, New York.

* * *

Sept. 19-22—Institute of Metals. Meeting at Book-Cadillac Hotel, Detroit. H. Foster Bain, secretary, 29 West Thirty-ninth Street, New York.

* * *

Sept. 19-23—Associated Machine Tool Dealers. Meeting at Hotel Hollenden, Cleveland. T. W. Carlisle, secretary, 1392 West Third Street, Cleveland.

* * *

Sept. 19-23—American Society for Steel Treating. Ninth annual convention at Hotel Statler, Detroit. National steel and machine tool exposition at Convention Hall. W. H. Eisenman secretary, 4600 Prospect Avenue, Cleveland.

* * *

Sept. 19-23—National Machine Tool Builders' Association. Exposition of machine tools at Public Hall, Cleveland. E. F. DuBrul, 630 Vine Street, Cincinnati, is general manager. Robert Everett, manager, Room 620, 225 West Thirty-fourth Street, New York.

* * *

Sept. 20-23—Iron and Steel Institute. Autumn meeting at Royal Technical College, Glasgow, Scotland. G. C. Lloyd, secretary, 28, Victoria Street, London, S. W. 1.

* * *

Sept. 26-30—National Safety Council. Annual congress at Hotel Stevens, Chicago. W. H. Cameron, managing director, 108 East Ohio Street, Chicago.

* * *

Oct. 25-29—American Institute of Steel Construction. Fifth annual convention, Pinehurst, N. C. Charles F. Abbott, executive director, 285 Madison Avenue, New York, N. Y.

# WITH THE EQUIPMENT MANUFACTURERS

## New Elwell-Parker Light Tier Tructor

A new lighter duty electric tiering tructor has been added to the Mill Type Series of the Elwell-Parker Electric Company, Cleveland.

This machine is designed to handle skid loads as in regular power-lift truck service or it elevates the load from the floor 4 to 8 ft. when tiering or stacking in storage, stock room, delivering goods to motor truck or to railroad car from rail level to car floor.

This is the two-ton tiering truck which completes the line of this type, the two previous sizes being rated three and six tons. The three machines cover the range for practically every high-lift operation required in industrial materials handling.

The new machine is of all steel construction and built on the interchangeable parts basis. The power plant is of the unit type i.e. enclosed Elwell-Parker motor, steel brake drum, steel multi-thread Brown & Sharp worm to bronze differential cage and cross, chrome vanadium drive shafts and universal joints to permit steering and the delivery of power to the steel clutch plates bolted to outside of drive wheels which are fitted with solid rubber tires and Timken tapered bearings. The third point support of the power plant is a ball beneath the drive motor.

## New Water Coolers at Homestead

Electrically cooled drinking water is to be provided 12,000 workmen employed in the Homestead works of the Carnegie Steel Company. The company announced, placing a contract with Frigidaire Corporation, subsidiary of General Motors, for more than 200 electric water coolers to be installed at once.

Efficiency tests recently completed by company engineers, disclosed that electric coolers afford constant temperatures, adjustable to any degree, furnish safer and better drinking water for men toiling in intense heat and in addition permit the company to effect a saving in ice bills and servicing costs of $40,000 a year. The expected annual savings, according to the announcement, will total more than one third the installation cost.

Two electric coolers were set up in the open-hearth section of the plant in 1926. Records were kept of drinking water temperatures obtained under actual working conditions where the thermometer sometimes rose beyond 130 deg. and cases of industrial cramps frequently occurred. The results formed the basis of the decision to similarly equip the entire plant.

## Link-Belt Announces Anti-Friction Belt Conveyor Idler

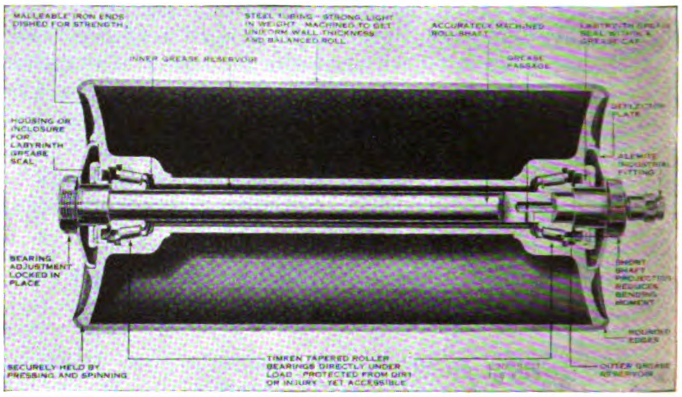
Announcement is made by Link-Belt Company, Chicago, of the introduction of their Anti-Friction Belt Conveyor Idler and Return Rolls of an advanced type of belt conveyor equipment.

This equipment embodies many salient features of advantage in design which are the result of years of study and research.

Bearings are Timken tapered roller bearing type, which are totally encased within the roll hub.

The outstanding feature of the idler is the absolute protection afforded by a labyrinth grease seal, mounted in a grease cup which also serves as an outboard reservoir and lubricates the bearing on the outside as well as on the inside, especially when the roll is on an incline. This, in turn, is protected by a deflector plate which deflects dirt, dust, grit or any foreign material away from the bearings and grease seal, and will not permit the washing of the grease away from the labyrinth.

The rolls are mounted on a self-cleaning "T" base. All rolls are interchangeable, being capable of serving in any of the three positions. The entire frame is riveted, and is without bolt or nut to work loose or to come out of adjustment.


MALLEABLE IRON ENDS DISHED FOR STRENGTH,
STEEL TUBING - STRONG, LIGHT IN WEIGHT - MACHINED TO GET UNIFORM WALL THICKNESS AND BALANCED ROLL
ACCURATELY MACHINED ROLL SHAFT
GREASE PASSAGE
INNER GREASE RESERVOIR
DEFLECTOR PLATE
HOUSING OR INCLOSURE FOR LABYRINTH GREASE SEAL
ALEMITE INDUSTRIAL FITTING
BEARING ADJUSTMENT LOCKED IN PLACE
SHORT SHAFT PROJECTION REDUCES BENDING MOMENT
ROUNDED EDGES
SECURELY HELD BY PRESSING AND SPINNING
TIMKEN TAPERED ROLLER BEARINGS DIRECTLY UNDER LOAD - PROTECTED FROM DIRT OR INJURY - YET ACCESSIBLE
OUTER GREASE RESERVOIR

Another advantage claimed is the close working tolerances to which all parts are built, closer than have ever been attempted in belt conveyor history.

The use of specially-constructed manufacturing tools assures alignment of bearings, and a well-balanced concentrically running roll.

Special care is exercised in the machining of the roll shell, to obtain uniformity of thickness of the wall into which the machined heads are pressed and securely held in place by spinning.

The heads are dished for rigidity and strength, and the entire construction is such as results in maximum strength.

## Hyatt Bearings Discernible

Several manufacturers of products in which Hyatt Roller Bearings are installed have asked the Hyatt Roller Bearing Company of Newark, N. J., for a method of making the presence of these bearings more readily discernible.

Compliance with these requests has produced the Hyatt "Mark of Bearing Protection." This symbol, represents a cross section of the characteristic hollow Hyatt Rollers in operating position around a shaft. This gears the legend—"Equipped with Hyatt Roller Bearings" in white letters on a red ground. The whole

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# NEWS OF THE PLANTS

Announcement has been made of the acquisition by the American Rolling Mill Company of Middletown, O., of the plants of the Columbia Steel Company, Butler, Pa., and the Forged Steel Wheel Company, Elyria, O.

The product of the Columbia Steel Company is wide strip sheets up to 36 in. These are produced by a continuous process which lately received wide publicity in the technical press. In acquiring the Forged Steel Wheel Company some months ago, the Columbia Steel Company added the output of this company—forged steel car wheels—as a product. A monthly tonnage of 10,000 tons of wheels and 36,000 tons of strip steel is thus represented by these two companies.

The American Rolling Mill Company, in July, commanded attention by presenting to the public a complete description of its method of rolling sheets on a continuous mill erected at Ashland, Ky. This description will be found in the July issue of The Blast Furnace and Steel Plant. At its Middletown, O., plant the American Rolling Mills operate 21 sheet and 3 jobbing mills; at Zanesville, O., 13 sheet mills, and at Ashland, Ky., 11 sheet mills and 3 jobbing mills.

The merger gives the American Rolling Mills a yearly capacity of approximately 600,000 tons of sheets which is about 20 per cent of the total output of the country.

* * *

Erie Foundry Company, Erie, Pa. has received an order for two drop hammers from an agricultural implement manufacturer in Vittoria, Spain. This company also received an order for a sheet galvanizing plant to be installed at the Sparrows Point, Md., plant of the Bethlehem Steel Company, Bethlehem, Pa.

* * *

A merger of the Bucyrus Company, South Milwaukee, Wis., and the Erie Steam Shovel Company, Erie, Pa., is supposed to have been virtually completed. After several details have been adjusted an announcement will probably be made this week.

* * *

The Dover, O., stack of the Hanna Furnace Company has been blown out. The Republic Iron & Steel Company has only two active stacks and only five out of 15 open hearths are operating. Steel making in the Youngstown district represents 65 per cent of capacity.

* * *

Construction of the proposed iron and steel plant of the Compania Electro Siderurgica E Industrial De Valdivia in Chile is to be started this fall. The company has nearly completed the process of legalization under the Chilean laws, consequently its plans have been approved by the government. These plans call for the construction of an hydroelectric plant for smelting iron ore and producing iron and steel. The capacity of the plant will be close to 50,000 tons of steel yearly at the start. Iron ore will be obtained from the Bethlehem Chile Iron Mines Company.

The appointment of a receiver for the Tacony Steel Company was demanded yesterday by the Bank of North America & Trust Company, a mortgage creditor to the extent of $300,000, the city of Philadelphia with an unpaid tax claim of $55,495, and the Penn Seaboard Steel Corporation with a claim of $2,000.

* * *

Liquidation of the Dominion Iron and Steel Corporation, Ltd., Sydney, N. S., one of the industries formerly connected with the British Empire Steel Corporation, was ordered July 12 by Mr. Justice Chisholm of the Supreme Court of Nova Scotia. The Royal Trust Company was named as liquidator.

* * *

The H. & H. Bolt & Nut Company, Inc., Schuylkill Haven, Pa., is completing the installation of machinery in a pipe nipple department and will be ready for the production about August 1. A bolt and nut department for which machinery has been purchased will go into operation later.

* * *

The Kalamazoo Malleable Iron Company, Kalamazoo, Mich. has completed additions of its plant. New air compressing, sand blasting, and hydraulic pressing equipment has been installed. Since the appointment of C. J. Edwards as president and general manager of the company, T. R. Collins has been made assistant general manager and James Linklater has been made works manager. The Kalamazoo plant is engaged in the manufacture of castings for the automotive industry.

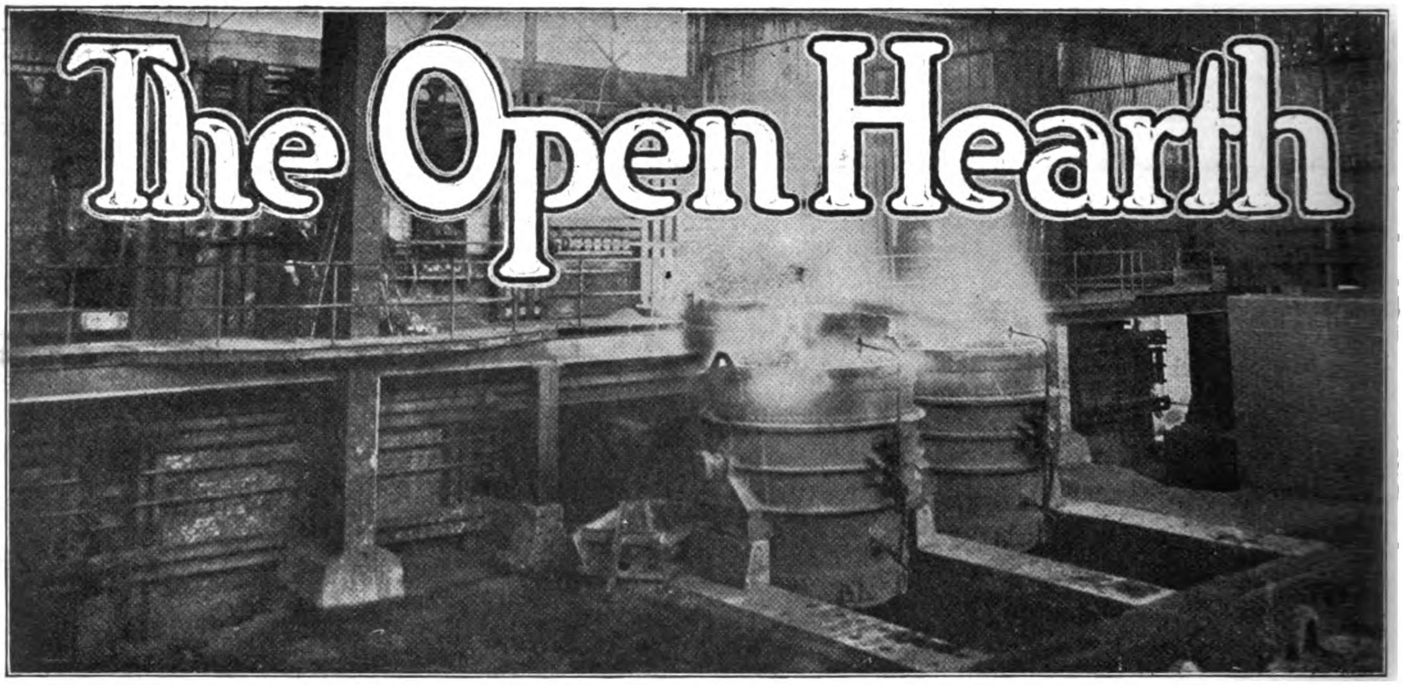
## American-Made Tools Popular in United Kingdom

American hand tools are recognized in the British market for their quality and dependability, a trade bulletin issued today by the Commerce Department states. The fine finish of American tools and the manner in which they are labeled and packed have been important factors in the sale of American tools in the United Kingdom, it is pointed out. British manufacturers realizing this fact have begun to adopt American patterns and advertise their tools as American type but British make.

According to the bulletin, 80 per cent of British imports of saws, 70 per cent of rasps and files and more than half of the carpenter's and engineer's tools are of United States origin. Germany ranks next to the United States as a supplier of foreign tools to the United Kingdom, while France, Sweden and Holland figure prominently in certain lines. Canada heads the list as a supplier of agricultural tools.

The United Kingdom, the report shows, is not only a large buyer of foreign hand tools but also a large exporter. The greater part of the British exports are destined for countries within the Empire although Latin American countries are becoming prominent in this trade, especially for agricultural tools. In 1925 Brazil alone accounted for fully 30 per cent of the entire British exports under this head.

# The Open Hearth



Theodore F. Merseles has been elected president of the Johns-Manville Corporation. H. E. Manville, who has served as president since the death of his brother T. F. Manville, in 1925, has been elected chairman of the board of directors. Mr. Merseles, who retires from the presidency of Montgomery Ward & Company, will continue as a director of that company and as chairman of its executive committee.

While the business activities of Mr. Merseles have centered in Chicago since he headed the Montgomery Ward organization in 1921, he has retained his interests in the east, where most of his business life has been passed. He will assume his new duties about August 15.

* * *

Mr. E. W. Beadel of New Castle, Pa., formerly president of the Pennsylvania Engineering Works, has just returned to the United States from South America where for the last two and one-half years he has represented the Bethlehem Steel Company in the capacity of vice president on a special mission in charge of constructing an oil refinery for the Argentine Republic.

* * *

Mr. A. L. Hollinger took charge of the Pittsburgh office of the Surface Combustion Company of New York, July 15, succeeding Mr. F. J. Winder, who left to take up work with the Allegheny Steel Company where he will be assistant to the general manager in charge of fuel.

Mr. Hollinger has had charge of the Chicago office of the Surface Combustion Company for some years, and will be succeeded by Mr. G. B. Ruby.

O. R. Olsen who formerly did engineering and sales work for the W. N. Best Company and more recently for a mid-western furnace company has also joined the Pittsburgh staff.

* * *

Harry D. Neach of the Sherman Engineering Corporation addressed the June meeting of the Grey Iron Founders' Association in Cleveland. Mr. Neach emphasized the need of introducing production economies, citing the backwardness of the foundries in installing incentive methods of wage payment as one example of some of the needs along production lines.

* * *

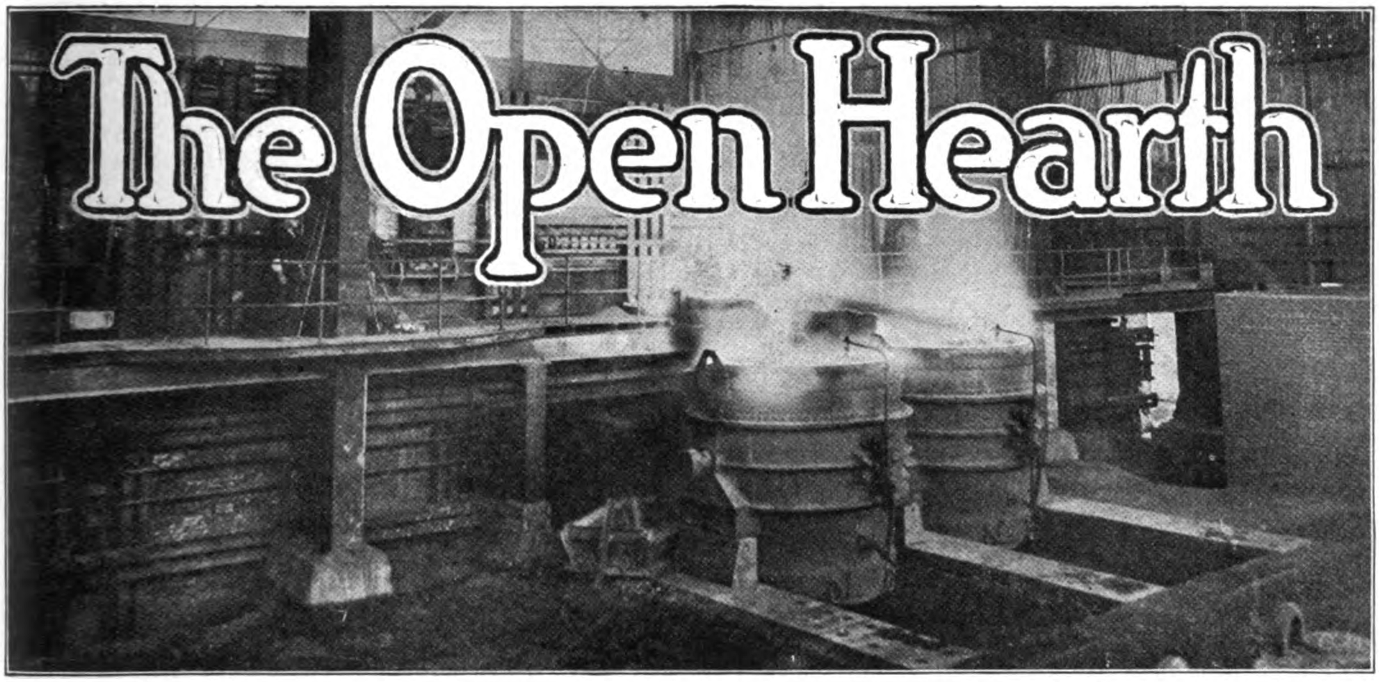
Mr. Aubrey J. Grindle, combustion engineer, has established his own company for the manufacture and sale of pulverized coal burning equipment. The company is known as the Pulverized Fuel Equipment Company and is located at 1238 Builders' Building, Chicago. Mr. Grindle recently was director and vice president of Grindle Fuel Equipment Company of Harvey, Ill., subsidiary of Whiting Corporation.

* * *

Burton L. Delack, assistant manager of the Schenectady works of the General Electric Company since December 1, 1926, has been appointed acting manager, effective July 1, according to an announcement by Vice President C. C. Chesney. Mr. Delack fills the vacancy caused by the promotion of C. E. Eveleth, elected a vice president June 1 of this year.

Edward A. Wagner, formerly of the Fort Wayne works, but since July, 1926, managing engineer in charge of all distribution transformers, with headquarters in Pittsfield, has been made acting manager of the Pittsfield works, succeeding Mr. Chesney, who has been a vice president in charge of manufacturing since the retirement of F. C. Pratt.

Giuseppe Faccioli, works engineer of the Pittsfield works, has been appointed associate manager and works engineer of the Pittsfield works, Mr. Chesney



# The Open Hearth

announced. These appointments were also effective July 1.

* * *

Mr. W. C. Schade has been placed in charge of the C. O. Bartlett & Snow Company's Pittsburgh office which is located at 406 Bessemer Building, Pittsburgh, Pa.

* * *

R. A. Smart has been appointed district sales manager, of the electric furnace division of The Metal Equipment Company of Cleveland, Ohio. His headquarters will be in Detroit.

* * *

Walter C. Carroll, vice president of the Inland Steel Company, Chicago, will resign, effective August 1, to assume the presidency of the National Association of Sheet and Tin Plate Manufacturers, with headquarters at Pittsburgh. Mr. Carroll entered the steel business in the mills of the American Sheet Steel Company in 1902, and was district sales manager for that company at Detroit in the following year. In 1904, Mr. Carroll was transferred to the Pacific Coast sales office and in 1906 he was moved to the St. Louis sales office. In 1921 he went to Chicago as vice president of the Inland company.

* * *

Major Victor E. Edwards, vice president and consulting engineer of the Morgan Construction Company, Worcester, Mass., was granted the degree of doctor of engineering at the June graduation exercises of the Worcester Polytechnic Institute, Worcester, Mass.

* * *

Julius S. Holl, advertising manager of the Link-Belt Company, Chicago, sailed for Europe on July 16. He will remain abroad for a month.

* * *

O. H. Davison, for some time sales representative of the Blair Engineering Company, New York, in Pittsburgh, has joined the United States Refractories Company, Mt. Union, Pa., as special representative. Vance M. Norton, Pittsburgh district sales manager, has been appointed district representative of the refractories company, with headquarters in Cleveland.

Thomas Windsor Evans, lately associated with the Pittsburgh Crucible Steel Company, Midland, as open-hearth superintendent, has recently become connected with the Vulcan Mold & Iron Company, Latrobe, Pa., in the sales and service division. Formerly Mr. Evans was open-hearth superintendent at the Toronto plant of Follansbee Brothers Company, general superintendent of steel work at American Tube & Stamping Company, Bridgeport, and electric furnace and plant No. A open hearth superintendent of the United Alloys Steel Corporation of Canton. His steel plant experience was begun at the Homestead plant of the Carnegie Steel Company.

* * *

Charles A. Alexander, general manager of the Tata Iron & Steel Company, Jamshedpur, India, arrived in this country for a stay of two to three months. During this time his headquarters will be with Perin & Marshall, New York. Mr. Alexander was formerly manager of the plant of the American Tube and Stamping Company, Bridgeport, Conn., and for some years was superintendent at the open-hearth department of the Donner Steel Company, Buffalo.

* * *

William S. Horner, formerly president of the National Association of Sheet and Tin Plate Manufacturers and chairman of the Sheet Steel Trade Extension committee, Pittsburgh, has been elected vice president of the American Rolling Mill Company, Middletown, O. Mr. Horner has for many years been a director of the rolling mill company, and a member of the executive board.

* * *

Robert L. Corbett, formerly sales manager for Hevi-Duty Electric Company, Milwaukee, is now associated with Mahr Manufacturing Company, manufacturers of oil burning equipment. He will represent the Mahr company as district representative in Ohio with offices in Dayton, O.

* * *

James Owen, for several years with the sales department of the Sharon Steel Hoop Company, Sharon, Pa., at its home office, is now connected with the sales office at Cleveland.

# TRADE PUBLICATIONS

The Hyatt Roller Bearing Company describes the many applications of roller bearings to steel plant equipment in a leaflet carry the title "Bearings—Dependable as the Steel You Make." Illustrations show these bearings in use on ingot cars, cranes, roller tables, blast-furnace skip cars, charging cars, ets. The leaflet is artistically arranged.

* * *

"Motor Drives for Rolling Mills," is the title of a publication released by the General Electric Company. This publication contains a partial list of main roll motors supplied by the company to January 1, 1927. Numerous illustrations are included.

* * *

Bulletin No. B-10 posted by the Link-Belt Company gives information regarding the service performed by "All-Purpose Crawler." It serves the purpose as the steam shovel, but is furnished with internal combustion engine or electric motor drive. It also performs the work of a drag line or crane. Capacities and dimensions are given. Copies of the bulletin may be obtained by addressing the Link-Belt Company, 910 S. Michigan Avenue, Chicago.

* * *

Catalogue No. 27, on Welding and Butting Equipment, issued by the International Oxygen Company, is somewhat of a treatise on the use of the tools mentioned. As a catalogue it is very complete.

* * *

The Thompson Electric Company, of 1438 West Ninth Street, Cleveland, Ohio, describes in catalogue B-27, the principle and operation, of the Thompson Hanger which supports electric lights. This hanger carries a reflector and is so constructed that it can be readily lowered for cleaning. It is recommended for machine shops, steel yards, railroad and automobile shops. Illustrations show the various type of hangers, their operation and application.

* * *

Of practical use to engineers, plant operators, and all who use belt conveyor equipment—is the 144-page Belt Conveyor Data Book No. 615 of the Link-Belt Company just off the press.

This 148-page book contains new formulae—new data—never published before; and it, undoubtedly, will prove to be as valuable a hand book on belt conveyors, as Carnegie or Kent are in their particular engineering field.

The most advanced designs of belt conveyor construction are covered, such as the Link-Belt Anti-Friction Idler, equipped with Timken roller thrust bearings.

This antifriction idler is made at the Ewart plant of Link-Belt Company, Indianapolis, to tolerances that are closer than have heretofore been attempted in the manufacture of belt conveyor idlers in belt conveyor history.

This book really goes hand in hand with the Typical Elevator Book No. 680, and the Link-Belt Silent Chain Drive Data Book No. 125, as in each of these three publications a deliberate attempt is made to so tabulate and arrange the fundamental facts, figures, and examples, as to make it easier for the prospective or potential user of such equipment, to do his own designing, and selecting, if he so choose.

* * *

Standards of The Hydraulic Society have just been issued in a fourth edition, comprising 80 pages, 8½ x 11 in. in size, which compares with a 19-page booklet, 6 x 9 in., published in 1921 as the first edition.

The new edition is profusely illustrated with charts, tables, drawings and half tones of pumps and pump parts and an effort has been made to produce a publication that will merit the approbation of the engineering profession.

## Germany to Manufacture "Armco" Iron

Arrangements have recently been completed between the Armco International Corporation, export subsidiary of The American Rolling Mill Company and Vereinigte-Stahlwerke, of Germany, for the manufacture of Armco Ingot Iron in the latter country.

Vereinigte-Stahlwerke was organized in 1926, combining the assets and business of four of the leading German coal, iron and steel concerns, viz., the Rheinelbe Union, Thyssen, Phoenix, and Rheinstahl. These groups, with their great plants on the Lower Rhine and on the Ruhr River, have for years held a dominating position in the German steel industry. Their combination constitutes the largest industrial unit outside the United States, with a total valuation of properties estimated at more than $500,000,000, and this powerful group is known as the big Steel Corporation of Germany.

Their mines and plants, with few exceptions, are equipped with modern machinery and operated economically and efficiently. All of the properties are well maintained in an excellent state of repair and in all ways compare favorably with the best of similar units in the United States.

The production of Armco Ingot Iron by this tremendous organization brings all operations from ore to finished product under one control. The Group owns and operates coal mines, coke ovens, blast furnaces, steel plants and rolling mills of all types, with a total estimated annual capacity of 37,000,000 tons of coal, 9,000,000 tons of pig iron, and 8,000,000 tons of ingots and castings. Approximately 164,000 men are on its payroll.

Its unexcelled finishing facilities will supply Armco Ingot Iron in practically all products that are at present manufactured from mild steel, such as rails, sections, tubes, sheets, wire, plates, pipe lines, etc.

The Armco Ingot Iron produced by Vereinigte-Stahlwerke will be sold by Armco-Eisen Gesselshaft, m. b. H., of Cologne, a company organized by the Armco International Corporation for this particular purpose.

Through the addition of this latest connection, the Armco International Corporation completes the rounding out of its foreign producing connections and Armco products will hereafter be manufactured in the United Kingdom, France, Belgium and Germany, in addition to the original plants in the United States.

Through the association with Vereinigte-Stahlwerke, the Armco International Corporation greatly improves its opportunity to fully serve with pure iron products its customers in important continental countries, such as Germany, Austria, Switzerland, Holland, Denmark, Norway, Sweden, Russia, Poland, Czechoslovakia, Hungary, Rumania, Bulgaria, etc.

# THE STEEL PLANT BRICK MASON

**A Section Devoted to Items of General Interest to Blast Furnace and Steel Plant Brick Masons**

## Drying and Firing of Clays

A report on this subject is now in course of preparation and will contain correlated data from three separate investigations. The first phase is confined to removal of moisture at and below 110 deg. C., as previously reported in Technical News Bulletin Nos. 101, 107, and 113. The second phase covers the so-called water smoking or removal of hygroscopic and chemically combined water, and the third phase covers an investigation conducted on plant kilns and which concerns not only problems of dehydration of clay but also oxidation.

From a consideration of information as brought out in the three investigations it would seem that materials of the fire-clay type are much more difficult to dry than the shales, but the temperature ranges of water smoking were more clearly defined for the fire clays than for the shales. Although the dehydration and oxidation of the shales appeared to be somewhat more sluggish than for the fire clays, there was no great difference in the time and temperature required for either type of material to reach final constant weight.

The results of the laboratory dehydration tests are being correlated satisfactorily with the observations and conclusions reached in the tests of commercial kilns, and it will probably be possible to predict, from data obtained in the laboratory, whether or not a clay could be dried and fired easily under commercial conditions, and if not, at what stages it would be necessary to use caution.

Probably the most important point brought out as a result of the work is that water smoking (the removal of hygroscopic and chemically combined water) offers no difficulty in itself, but that the time required to fire ware is controlled by the relative ease with which the ware can be dried (the removal of shrinkage and pore water) and oxidized. It is believed that the difficulty encountered in firing ware is not caused by the removal of hygroscopic and chemically combined water, as initially contained in the clay, but rather by ~~the~~ water which has been driven out of the ware in the hotter portions and which may be reabsorbed by the ware in the colder portions and soften the ware sufficiently to cause kiln marking and cracking. It may also recombine as shrinkage water, and its removal in this form might easily cause cracking if the clay is of the "difficult drying" type.

While the preparation of the report is nearing completion, it will probably be several months before it is published and available for distribution.

—Bureau of Standards News Bulletin.

A man known, by reputation at least, to all open hearth furnace men is "Sam" Naismith, who was "snapped" as he was making his morning inspection trip. Mr. Naismith besides being the inventor of the "Naismith sloping backwall," is also superintendent of masons at the South Chicago plant of the Illinois Steel Company.

## Sillimanite Bricks

Sillimanite has been successfully used in the construction and repair of the sieges of pot furnaces, the mixture used being 75 sillimanite to 25 plastic fireclay. One such siege showed very little wear after three years in use. A sillimanite brick roof to a 3-ton Heroult electric furnace used for steel-melting at Sheffield lasted 132 heats, and the volume change of the bricks during use was negligible. The normal life of a silica brick roof on this furnace is 60 heats.

Sillimanite bricks are giving very promising results in the arches and walls of high-pressure boiler furnaces with normal coal-firing and also with oil and pulverized-coal firing. Sillimanite shelves on the trucks of tunnel ovens are also giving good results. The mechanical strength at high temperatures of well burned sillimanite bricks with 15 to 25 per cent of fireclay bond is much superior to that of fireclay bricks.

—Chemistry and Industry.

## Experiences with Refractories in Furnace Construction*

By Leo W. Briggs†

Progress in the development of furnaces depends as much upon the development of refractories as does the advancement in the automobile industry depend upon the properties shown by alloy steels, which are so widely used at present. Although refractories cannot be compared with metals with regard to developing or maintaining definite properties, it is believed that advancement could be made in obtaining more exact information on the properties of various types of refractories in service.

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*Abridgment of paper presented at the meeting of the American Refractories Institute, held in Atlantic City, N. J., May 18, 1927.

†Surface Combustion Company, New York, N. Y.

It is so that the greater part of refractories is consumed in the making of iron and steel, but there is a large outlet for the use of refractories in special types of furnaces. The extent of this consumption is dependent largely upon the properties that can be developed in a given refractory. For instance, large automatic furnaces involve many considerations other than that of refractories for example, the conveyors, combustion principles and automatic controls, but it is believed that 90 per cent of the troubles are directly due to the refractories. Furnaces can be designed to make use of the present refractories and obtain good service, but this is done at the expense of good operation and efficiency. It is realized that one refractory material cannot incorporate all of the desirable properties, but advancement no doubt can be effected along this line.

Experience has shown that the manufacturer often has very little specific information regarding the properties of his products. Recently a salesman from a refractories company requested that his product be given a trial, telling of an installation which had used his brick, giving very good service. He was very enthusiastic over the life of these refractories, but when asked whether the furnace atmosphere was reducing or oxidizing he did not know. It could not be stated whether the fuel used was gas or oil.

Experience has shown that the type of fuel is of major importance in the life of refractories. It is found that in a general way a certain type of refractories stands up better in an oil-fired furnace than in one fired by gas. An explanation of this cannot be offered, although an important factor is that small combustion tunnels are used with gas burners. These tunnels being made of the refractory are subjected to the high temperature of the ignited gas. In the case of the oil burner combustion takes place more in the furnace and produces a glaze on the surface of the refractories, which seems to protect them, giving longer life. It is desirable to reduce the flame of the combustion chambers to increase efficiency, so that combustion engineers are concerned with the development of more suitable refractories. It has been shown that it is possible to develop as high as 550,000 Btu. in a cu. ft. of combustion space in one hour. This is equivalent to burning more than 1,000 cu. ft. of city gas in this volume for this period. Manufacturers of refractories argue that combustion chambers should be made larger, reducing the severity of furnace conditions, and it is admitted that such a design would allow the use of refractories which are of the least expensive type, but such a practice would not be advancement. With more efficient furnace designs, a higher grade and higher priced refractory can be used.

Considerable use is made of silicon carbide, but this material requires reducing atmosphere often at comparatively low temperatures. Its high thermal conductivity is often of great value, especially in the case of muffle furnaces, but it is not always feasible to operate these with a reducing atmosphere. A furnace was constructed for use in firing an enamel containing lead oxide, which requires an oxidizing atmosphere. In this installation considerable silicon carbide was used and after having operated for a while at a temperature between 1,700 and 2,200 deg. F., the silicon carbide failed to the extent that it could be shovelled out of the furnace. With reducing atmosphere this material may be used at high temperatures, but an oxidizing atmosphere is very detrimental.

Furnaces employing silicon carbide give better service when fired with oil burners. It is desired, therefore, to obtain a refractory which will exhibit the properties of silicon carbide at temperatures as high as 2,500 deg. F. in an oxidizing atmosphere.

Another type of material which should be highly desirable for furnace doors would be a light weight refractory which would eliminate the present type of door, namely 4½ in. of fire brick and the same amount of insulation. Such material would allow the construction of a less bulky and lighter weight door, simplifying the design.

Progress in the immediate future can be increased through a closer co-operation between the consumers and producers of refractories. More specific information should be obtained regarding the behavior of furnace linings under varying conditions of service. A more liberal exchange of experience between these parties would greatly assist in the proper application of various types of refractories.

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## Fall Meeting American Refractories Institute

The fall meeting of the American Refractories Institute will be held on Thursday, September 15, at the Clifton Hotel, Niagara Falls, Canada. Some very interesting subjects will be up for consideration.

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## Production of Refractories

"The country, whether it knows it or not, is dependent on refractory materials as primary products on which the production of others rests. They stand in the same relation to other products as the hidden foundation bears to the complete building."

—Charles Catlett.

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## Advertising Manager for Furnace Specialties Company

Mr. W. S. Quigley, president of the Quigley Furnace Specialties Company, Inc., has announced the appointment of J. W. Marshall as advertising manager of this organization, engaged in the manufacture of Hytempite, a plastic refractory cement for bonding firebrick and kindred uses.

Mr. Marshall comes to the Quigley organization direct from the Westinghouse Electric & Mfg. Company where he was manager of the publicity division of their Pittsburgh office. He has specialized in industrial advertising and has been connected in the past with the American Nickel Corporation, where he served as assistant sales manager, and G. P. Blackiston and staff, as manager of the creative division.

Mr. Marshall assumes his new duties with more than 15 years' experience in advertising, promotion of sales, editorial and engineering experience. He is a member of the American Society of Mechanical Engineers and a graduate of Cornell University. His headquarters will be at the company's New York office, 26 Cortlandt Street.

# SAFETY FIRST IN THE STEEL PLANT

**Section Devoted to the Interest of the Safety Movement**

## The Business Facts of Safety

### Fact No. 2

Mechanical safeguards are helpful, but are not sufficient.

The leading industrial executives and engineers who have saved millions through safety work, testify unanimously that mechanical guards can prevent only a small fraction of the preventable accidents.

The human mind — which controls human action—cannot be surrounded by a mechanical guard.

Make sure your employes are encouraged to think and work safely.

—National Safety Council.

## Governor Paulen of Kansas Says

We must organize Safety Councils to point the way to the youth of the country. It is a matter of education. It is building for the future. We must think in terms of our duty to posterity, as our fore-fathers planned when they laid the foundations of the mightly region embraced in the call for this safety congress.

* * *

I want to declare my firm faith and belief in the truth, that no permanent results will come from any movement for the safety of human life and betterment that does not begin with the children in the homes and the schools.

For the welfare of the state and nation, child life must be protected in the right to live, to grow, to learn and to develop into useful citizenship.

* * *

We are beginning at the fountain head by making Safety a part of the curriculum of the public schools. We will thus build a public sentiment for the future with a foundation on the solid rock of education.

—Public Safety.

The first man to profit by a tip on Safety was Noah who thereby cornered the stock market.

## Jones & Laughlin Report Reduction in Accident Severity

Much interest is being exhibited by the workmen in the contest for the trophy of the Jones & Laughlin Steel Corporation, and a considerable decrease in the number of industrial accidents is being experienced.

The following is the reduction in Accident Severity so far this year compared with the corresponding month last year:

January, 72 per cent; February, 77 per cent; March, 86 per cent; April, 86 per cent.

**Accident Prevention Trophy of the Cambria Plant of The Bethlehem Steel Corporation. This trophy is awarded to the department showing the greatest decrease in accidents over a five year period. The inscription is: "Let the Spirit that gave us the Kelly Converter lead us forward to better and safer methods."**

## People Must Develop Safety Consciousness

In order to check the rapid growth of industrial accidents in the state of New York, people will have to get the safety habit or develop a "safety consciousness," declared Labor Commissioner James A. Hamilton in an address on "Safety" recently at the annual rally of the Metropolitan New York section of the National Electric Light Association at the Knights of Columbus auditorium, Eighth Avenue and Fifty-first Street.

Commisioner Hamilton emphasized that safety, like other things is largely a matter of habit not only in industrial life, but in all forms of activity. He urged that industrial workers, especially, develop a "safety consciousness."

He had called attention to the fact that industrial accidents have increased 50 per cent for the five years ending last June 30, as reported under the workmen's compensation act. The figures show they jumped from 293,844 in 1922 to 441,401 in 1926, not including agricultural and domestic laborers and workers in industries not conducted for pecuniary gains.

In 11 years Bethlehem Steel Corporation has reduced accidents 60 per cent.

# TRADE NOTES

Announcement is made of the consolidation of the Power Specialty Company and the Wheeler Condenser & Engineering Company. These two old established concerns have been pioneers in many new engineering developments and are among the strongest and most highly respected of the manufacturers building auxiliary power plant and oil refinery equipment.

The assets, plants, engineering, research, sales departments and subsidiaries of both companies will now be assembled under one corporate, identity to be known as the Foster Wheeler Corporation. No changes in products are contemplated as there has been no competition or overlapping of effort in the past. The products of each company complemented those of the other, but there is the great advantage that both were sold to the same industries and often to the same customers. The most widely known products of these companies—and they have been installed in every continent in the world— are superheaters, economizers, water-cooled furnaces, air heaters, tube stills, unit coal pulverizers, condensers, pumps, cooling towers, feed water heaters, evaporators, fractionating equipment and heat exchangers. These are built at Dansville and Newburgh, N. Y., at Cartaret, N. J., St. Catharines, Ontario, Canada and at Egham, Surrey, England. The companies have branch offices throughout this country and subsidiaries in Canada and Europe. Thus, the combination of departments will effect valuable economies and the increased plant facilities with greater volume and buying power are certain to result in desirable savings.

No change in management will be made and former conservatism coupled with most advanced research and engineering will be maintained. The new officers will be those of the old companies as follows:

Mr. J. J. Brown, chairman of the board of directors; Mr. Pell W. Foster, vice chairman and treasurer; Mr. L. B. Nutting, president; Mr. John Primrose, vice president; Mr. H. S. Brown, vice president; Mr. W. E. Dowd, Jr., vice president; Mr. David McCulloch, secretary and general manager; Mr. W. F. Keenan, Jr., chief engineer.

The financial strength will be even greater than heretofore. The new corporation will have no securities prior to 35 000 shares of preferred stock and 194,000 shares of no par value common stock. The combined assets are approximately $12,000,000.

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The Ingersoll-Rand Company in order to provide better sales and service facilities for its customers in northern New Jersey and certain adjacent counties of New York state has opened a branch office at 236 High Street, Newark, N. J. Mr. F. K. Armstong, formerly connected with the company's New York sales branch, has been appointed manager.

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William Swindell & Brothers of Pittsburgh, Pa., have acquired the Kupfer interests in the American Dressler Tunnel Kilns, Inc. The American Dressler Tunnel Kilns, Inc., are designers and builders of three types of kilns, namely, the Dressler Muffler Kiln; the Dressler Direct-Fired Kiln and the Dressler Regenerative or Cross-Fired Kiln, and maintain their own laboratory for properly testing materials to be treated in their kilns. Dressler kilns have been used successfully for the past 12 years in all lines of iron and steel annealing, and also in the burning of brick.

## New Steel Plant Book

"Methods of the Chemists of the United States Steel Corporation for the Sampling and Analysis of Gases." 187 plus XIV pages, 25 illustrations, 6 x 9 in. paper. Published and sold by Carnegie Steel Company, Bureau of Instruction, Pittsburgh, Pa. Price $2.00.

This book is the result of more than two years' work of a special committee composed of chief chemists of the subsidiary companies of the United States Steel Corporation. The book is divided into four parts dealing with different phases of gas work as follows:

Part I—Occupying the first 44 pages, is devoted to apparatus, reagents and absorbing solutions. In it are found a brief discussion of the sources of error in gas analysis, a detailed description of the construction, operation and care of the new apparatus adopted, and a section on the preparation and properties of reagents and solutions used in gas analysis.

Under the heading of absorbing solutions and reagents, practically all these substances heretofore used for gas analysis are discussed, and two new absorbents of exceptional merit, one for carbon monoxide and the other for oxygen, are described.

Part II—Covering 60 pages, deals with the sampling and the analysis of industrial gases with the apparatus described in Part I. Detailed directions are given for the sampling and analysis of flue and chimney gases, blast furnace gas, producer gas, byproduct coke-oven gas, coal gas, blue gas, carburetted water gas, natural gas, mixtures of natural and coke-oven gas, mine air, and compressed, or cylinder gases.

Part III—Includes 33 pages, and deals with miscellaneous determinations that cannot be made with the regular gas analysis apparatus. In this section are described methods for the determination of hydrogen sulphide, organic sulphur, total sulphur, acetylene, hydrocyanic acid and cyanogen, light oil or benzene, tar and mineral solids, naphthalene, moisture, and dust in gases. Methods for determining the heating value and the specific gravity of gases are also included in this section.

Part IV—Comprising the last 47 pages, deals with the measurement of gases, the calculation of gas volumes under different conditions, and a number of problems presented by the combustion of gases. An appendix, composed of 12 tables, gives the specific gravity, the weight per liter and per cubic feet, the Btu. values and the specific heats of gases under the standard conditions selected, the properties of water vapor, factors for the correction of observed calorimeter readings, and a long list of conversion factors.

The book is more than a description of methods. It emphasizes the importance of accuracy and recognizes the fact that accuracy is not to be obtained in every case by a blind following of directions. It contains a great deal of information on the sampling, analysis, measurement and combustion of gases, which makes it a work of interest not only to chemists, but also to combustion and efficiency engineers, students, and, in fact, anyone interested in the combustion and handling of fuels.

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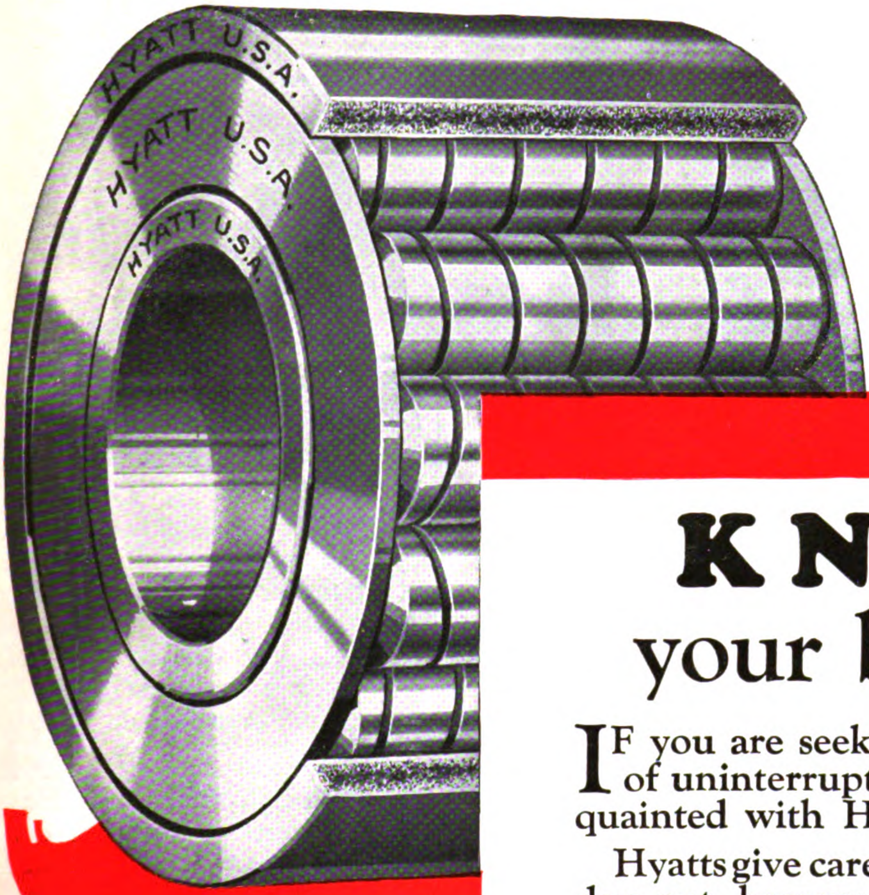
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